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ABSTRACT

This study examined the extent to which college students were affected by and remembered color information within instructional materials. Factors studied were color codability, verbal cueing, type of question, stimulus silhouettes, and prompting. These factors were included in stimulus scenes for study via two 16mm motion picture films. Color silhouettes, included in the films, were presented for testing. Subjects responded to color names in one film and to color patches in the other. High and low codable colored stimuli were included with the simple object and geometric shape silhouettes. Half the items asked color questions while the other half asked position questions. Subjects scores were analyzed by a multifactor ANOVA with repeated measures. Results indicated that higher scores were achieved with high codable colored stimuli than with low, color names were not always easier to remember than color patches, higher scores were achieved with position items than with color items and with simple object stimuli rather than geometric shape stimuli. Differences appear to exist between colors as they interact in instructional materials. (Author/CJ)

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A STUDY OF COLOR IN INSTRUCTIONAL MATERIALS AND ITS EFFECTS UPON LEARNING

FINAL REPORT

March 1970

By

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U. S. Department of
Health, Education, and Welfare
Office of Education
Bureau of Research

Final Report

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March 1970

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SUMMARY

This study examined the extent to which undergraduate college students were affected by and remembered color information within instructional materials. The five factors studied were color codability, verbal cueing, type of question, stimulus silhouettes, and prompting. These factors were included in stimulus scenes for study via two 16mm motion picture films.

Colored silhouettes, included in the two films, were presented to subjects (Ss) for testing. The Ss responded to color names in one film while in the other they responded to color patches. High and low codable colored stimuli were included with the simple object and geometric shape silhouettes. Half of the items asked color questions while the other half asked position questions.

In addition, half of the items were prompted while the other half were not. All treatment conditions were randomized throughout each film to control for practice and fatigue effects.

Eighty-six male and female undergraduate students volunteered for the experiment to fulfill a course requirement. They were screened for color blindness and then randomly assigned to view one of the two films in an experimental session.

Their scores were analyzed by a multi-factor ANOVA with repeated measures. All factors in the analysis were assumed to be fixed since

the levels were selected by a systematic procedure.

It is indicated by the results that higher scores were achieved with high codable colored stimuli than with low codable colored stimuli, color names were not necessarily easier to remember than color patches, higher scores were achieved with position items than with color items, higher scores were achieved with simple object stimuli than with geometric shape stimuli, and Ss scored higher on prompted items than on non prompted items.

On the basis of the analysis of the results, differences appear to exist between colors as they interact in instructional materials. It is suggested that additional latency measures be made between direct viewing of color chips and transparent color film. Thus, statements about the effects of color codability on memory of stimuli could be made more readily. Also, it would seem that there is a need for the development of a color codability scale since color codability does not relate directly to the Munsell notation system. In addition, continued study of information processing would be warranted. Finally, this research did not clarify completely the effects of stimuli meaningfulness on learning. Thus, further research is needed.

INTRODUCTION OF THE STUDY

Statement of the Problem

It is inferred from earlier research that little is known about the effect of color used in instructional materials upon learning (Kanner, 1959). This research attempts to provide information concerning the dynamics of color and other selected factors which may interact and affect learning. Its specific purpose is to examine the extent to which undergraduate college students are affected by and remember color information within instructional materials.

In examining the problem, the following questions were investigated.

1. To what extent do colors characterized as <u>low</u> <u>codable</u> and <u>high</u> <u>codable</u> affect learning?
2. Does verbal cueing or labeling of colors improve or impede the memory process?
3. Is there any relationship between an individual's test score and the subject matter selected for testing?
4. Are there any particular shapes or forms which seem to be easier to remember than certain other shapes or forms?
5. Does a prompting condition contribute more to information memory than a non prompting condition?

In attempting to determine answers to these questions, the following null hypotheses were tested:

1. There is no difference between subjects' (Ss') average performance on high codable colors as compared to low codable colors.
2. There is no difference between the mean criterion performance of Ss who viewed Film A as compared to Ss who viewed Film B.
3. There is no difference between Ss' average performance on color items as compared to position items.
4. There is no difference between Ss' average performance on simple objects; i.e., objects commonly experienced, as compared to geometric shapes.
5. There is no difference between Ss' average performance on prompted items as compared to non prompted items.

The dependent variable used throughout this study was the adjusted-mean number of stimulus items within a treatment condition to which a S responded correctly.

Definition of Terms

In making the problem more specific a number of terms need to be defined. The terms used in this study are defined in the following paragraphs.

Munsell color system. The Munsell color system has been described as a colored solid sphere with three notations: hue, value, and chroma. Value is measured on an axis from the north pole to the south pole. The north pole of the sphere is white and the south pole is black with varying degrees of gray falling in between. By encircling the sphere at the equator, one would view each hue or color at its highest chroma or saturation level since saturation increases as one moves from the core to the surface of the sphere (Kelly and Judd, 1955).

Munsell notation system. The Munsell notation system is written in this order: hue, value, and chroma. Any given hue will vary along a 10-point scale. Therefore, a notation of 5P 3/10 would be read as: 5P, purple at the mid point of its 10-point spread; 3, value or degree of lightness; and 10, chroma or degree of saturation (Kelly and Judd, 1955).

Color codability. Some colors are named with a single, short word while others require a series of words. For example, one color may be called red; while another may be labeled deep red; and a third, very deep red. The color name length seems to correlate highly with the time required to recognize and to name that color. In the literature, this effect has been labeled color codability (Brown and Lenneberg, 1954).

Verbal cueing. Individuals attach labels to colors, objects, and other stimuli to help them categorize important information for future recall and dissemination. Verbal symbols and cues seem to be the key to efficiency in this process (Whorf, 1956).

Prompting. In this research, a cue or a prompt focuses attention and reduces uncertainty in the stimuli making it possible for the learner to concentrate on a given aspect of the problem.

Meaningfulness. Meaningfulness denotes the degree to which an object, word, concept, etc. is interpretable, and its assigned role in a language is commonly understood (Webster's Seventh New Collegiate Dictionary, 1967).

Memory. Memory is the ability to recall information that has been assimilated at an earlier time (Webster's Seventh New Collegiate Dictionary, 1967).

Stimulus scene. In this research, colored chips were cut into a total of five geometric shapes and five simple objects. From these materials, four were selected randomly to appear in a specified location on one of five distinct backgrounds. In addition, each shape or object randomly represented one of the eight Munsell colors. These plus the item number; a narrow black band; and the audio track, where specified, constituted the two-second scene of each of the 320 items found in each film. This information scene, found in all items, is referred to as a stimulus scene.

Treatment condition. In this study, the crossing of the two levels of all factors A, B, C, D, and E are represented in the stimulus scenes. Thus, the stimulus scenes embody or incorporate all of the possible stimulus combinations. Each possible stimulus combination is referred to as a treatment condition, and each film has sixteen unique treatment conditions.

Simple objects. In this research, this term refers specifically to the cut-out silhouettes used; namely: dog, truck, umbrella, key, and bird.

Geometric shapes. This term specified the rectilinear and curvilinear silhouettes used in the present study; namely: triangle, square, star, circle, and diamond.

Color item. In this study, a color item was a criterion question which examined the Munsell color of a specific object or shape presented ten seconds earlier.

Film A. In the present research, this film required Ss to respond to color questions by selecting a color from an array of eight color names; i.e., orange, brown, etc.

Film B. In the present study, Film B is identical to Film A in every other way except that Ss are required to respond to color questions by selecting a color from an array of eight Munsell color patches or chips.

Background of the Problem

Color may be examined under a myriad of conditions involving many criteria. Thus, in the present study, an early decision directed the investigator to examine the effects of color on memory. This goal was selected since memory often is applied in instructional objectives.

The color components chosen for study were derived from the earlier research work of Brown and Lenneberg (1954). In their color study, Brown and Lenneberg recognized that related colors, as perceived by English-speaking individuals, are often labeled differently. Their findings indicated that the color name length correlated highly with the response time Ss required to recognize and to name a color. This was their best measure of a factor which they labeled codability.

The concept of codability constituted a major factor of interest in the present study. It was felt that color codability might have an effect on memory especially since Brown and Lenneberg's Ss seemed to have difficulty naming or coding some colors more than others.

Color also was related to verbal cueing. An attempt was made to determine whether different verbal cueing levels affected the learning process. Since it was suspected that the degree of verbal cueing provided might have some effect on color stimulus recall, a decision was made to include it as a factor in the present study. This decision was based in large part on the theories of Kanner (1959), Whorf (1956), as well as Brown and Lenneberg. This factor essentially was examined through the method of color questioning used in the study; i.e., Film A compared to Film B. Hopefully, the verbal cueing factor plus the codability factor would provide a better understanding of the dynamics involved in the effects of color on memory.

Another factor was considered which might indicate what priorities individuals establish in information processing. Essentially, the stimulus topic or information selected for testing might affect an individual's test proficiency. Color and position questions represented the stimuli selected for testing. In addition, this factor may have required the Ss to process and assimilate more of the stimulus package, thus, preventing Ss from concentrating solely on color information.

Since color may be examined under a variety of presentation conditions, a decision was made to consider, in a systematic fashion, the shape or form of colors included in the study. It seemed possible that shapes and forms might have different degrees of meaningfulness. Since color meaningfulness has been related to response latency by Brown and Lenneberg, then perhaps the selected shapes might affect the Ss' utilization of color information. If given the color requirements of a stimuli, there just might be a particular shape or object which facilitates learning more than another shape or object.

Every stimulus condition normally contains x-number information parts which, when considered as a whole, affect the difficulty level of the task and the amount of information that can be assimilated. By introducing a cue or a prompt, one may be able to focus attention and reduce uncertainty making it possible for the learner to concentrate on a given aspect of the problem. Perhaps the greater the prompting level included in a stimulus condition the greater that stimulus condition would contribute to information memory.

Instructional materials often contain color information which may have unique effects on individuals. In this research, color has been combined under as many instructional like conditions as feasible within a single study. Thus, it is hoped that this research, first, will help explain, to some extent, how individuals utilize color in instructional materials. Second, how do the unique effects of color relate to other select variables within instructional materials? These questions are most important for year after year educators continue to spend additional funds for color in instructional films and television equipment and materials. Yet, it is apparent that little is known about the unique effects of color on learning.

REVIEW OF RELATED RESEARCH AND LITERATURE

Color, a stimulus condition often found in instructional materials, is perhaps the most striking attribute of our physical world yet is still somewhat an unknown in its educational effects. In the literature in the field of education, there are studies in which the practical and applied questions concerning the ability to profit from and use color information were examined. Psychological literature also reveals many studies concerned with human color perception and color memory; research has examined questions of color recall, color impact in illustrations, the "realism" of black-and-white film, the particular value of color cues in learning, and other color effects related to the individual learner. Yet, in spite of these earlier studies, research findings still do not explain fully the special effects of color in instructional materials (Kanner, 1959).

Physiological Conditions and Color

In a study by Overton and Brown (1957), the Pseudo-Isochromatic test plates were administered to 74 Ss as a check against color blindness. Then each Ss was asked a question about standard traffic lights. The question was: "On most traffic lights, is the red light or the green light on top (p. 126)?" Time required for making a color name response was recorded for each Ss. Results showed that:

> . . . Ss with some color weakness tended to give quick, correct answers to the question about the traffic light. In other words, there was a tendency for defective color vision to elicit compensatory learning even in Ss who were not aware of their slight deficiency (p. 126).

In some studies, the age of Ss seems to have marked effects on color-matching ability and on color-word interference performances. Gilbert (1957) used the Color Aptitude Test to study age effects which arise in male and female Ss in color matching. Over 350 Ss between the ages of 10 and 93 volunteered to take the test. The Ss were required to draw color chips randomly from a container and match them against identical color chips mounted on a board. Each S recorded his choice by writing the number on the back of the loose chip beneath the one chosen on the board. Data analysis indicated

> . . . a rise in separate and total color scores from the first decade (10 to 19 year group) to the twenties with a subsequent steady decline.
>
> Shades of blue and green proved to be more difficult to discriminate between than shades of yellow and red at all ages, and the ability to discriminate between these shades likewise showed a more rapid decline with age.
>
> At all ages, but particularly in the sixties, wide individual differences were found in ability to match colors. Females showed an inconsistent tendency to score better than males at certain decades of life and also on certain colors (p. 215).

Contribution of Color to Realism

Rudisill (1952) studied the contribution of color to realism in illustrations commonly found in children's books. The stimulus materials were derived from five categories of illustrations; namely, an uncolored photograph, a colored photograph, a realistic colored drawing, an outline drawing, and a colored drawing unrealistic in color. Three picture themes served as content and each was "copied" in the five varying art forms. Then several hundred K through sixth grade Ss determined which of the fifteen pictures they liked best. She found that a child looks at a picture first, ". . . to recognize its content," and second, that ". . . any picture (assuming a certain content) proves satisfying to the child in proportion to its success in making that content appear real or lifelike," and third, that ". . . color in pictures proves satisfying to the child in proportion to its success in increasing the impression of realism or life-likeness (p. 451)." The child was said to utilize color to enhance his conception of reality only after earlier considerations are satisfied.

McCoy (1962) sought to determine if "in film-mediated perception, color is more likely than black and white to evoke an audience's rated perception of reality in a film scene (p. 70)." Four 10- to 20-second film scenes were planned. Three of the scenes were staged while the fourth was taken from an unrehearsed newsreel event. All scenes were filmed in color, and both black-and-white and color versions were printed. Sixty-one college student Ss saw all four black-and-white scenes while one hundred and three college student Ss were shown the four color scenes. The objective was to determine whether each scene was real or staged. Results indicated that in three scenes out of four the black-and-white rendition ". . . elicited a higher percentage of responses indicating belief that the scenes were shot from actuality (p. 71)."

McCoy admitted that the findings were sketchy but concluded that:

> . . . the hypothesis that color is superior to black and white in eliciting an audience's rated perception of reality in film scenes is not clearly supported by the evidence. A slight trend, on the contrary, is evinced favoring black and white. . . . but there might possibly be here some mild support of VanderMeer's contention that when color is used in film, audiences are less apt to take notice of, or be affected by other cues (p. 72).

Color or Black-and-White

Several studies have shown no significant differences in the performances of learner groups who viewed material either in color or black-and-white. VandeMeer (1952) studied the effects on learning of black-and-white and color versions of the same films in two experiments. In the first experiment, five color films differing in content were shown to approximately 250 high school science students. Black-and-white prints of the same films were shown to another 250 students. They were pretested with an instrument that presented contents from all the films. Then immediately after viewing each film, the Ss were tested again with the items appropriate to each. Finally, the combined instrument was administered about six weeks after the film viewings. In the second experiment,

> . . . students were divided into six class sections of approximately forty students each, and . . . odd-numbered sections saw color prints of films A and C, and black-and-white prints of films B and D. Even-numbered sections saw color prints of films B and D, and black-and-white prints of films A and C. . . tests of learning were administered immediately after each film showing but no delayed recall tests were given (p. 4).

In all, 699 students saw the films. Results indicated that,

> 1. Both films produced learning.
> 2. There was no greater learning from the color films.
> 3. Information presented in the color films was remembered longer.
> 4. Color films were liked better than black-and-white films.
> 5. Subject content had a greater effect on the liking for a film than the effect of black-and-white or color (p. 1).

The observed differences were small and mixed. One recommendation from the studies was "training films should be produced in black-and-white because the increased cost of color film is not offset by increased learning (p. i)."

Color Perception and Memory

One broad question that has been insufficiently studied is how people deal with and learn from color cues in instructional materials. Baker and Mackintosh (1955) studied the degree to which color judgments are "functions of past color associations, 26 Ss were shown six nonsense form-color name pairs 14 times each and then were asked to match from memory. . . (p. 286)." They found that an individual's past experience with color associations was one of the factors that could be used to explain current color judgments made by an individual.

Newhall, Burnham, and Clark (1957) compared successive and simultaneous color matching. The Ss made ten perceptual matches and ten memory matches of each of the twenty-five test colors. Regular binocular vision was used for the color matching. Results indicated that memory matches were more variable than perceptual matches, and there was a tendency for the memory colors to shift in hue and increase in saturation.

In summary,

> The successive or memory method yielded (1) the higher variability of replicative matchings, (2) the shorter matching times, (3) systematically higher purities, and (4) somewhat higher luminances. . . . This increased apparent strength of the remembered colors seems to be a direct consequence of the selectivity of memory (p. 43).

Bartleson (1960) found similar results while studying Ss' ability to remember the colors of common objects. This ability was labeled "memory color" and was defined as ". . . an individual's standard of recollection for familiar objects and, because of the frequency with which certain object-perceptions are repeated, these memory colors probably tend to be relatively stabilized (p. 73)." He theorized that routine objects, scenes, or landscapes that have common visual impact will probably produce memory colors common to most people. In this study, objects like red bricks, green grass, or evergreen trees were named by the experimenter. Then from memory, fifty Ss were required to select, from Munsell color patch samples, colors that corresponded to each of the ten objects. Following this, the color selected for an object was compared with the "natural mean" for that object. The "natural mean" colors for the ten objects were obtained from data collected in earlier studies. For example, the color of green identified by Ss was compared with the "natural mean" for green grass.

From this study Bartleson concluded that,

> There is evidence of increased saturation in the memory colors. In most cases there are hue shifts with memory in the direction of what is probably the most impressive chromatic attribute of the object in question (p. 77).

In other words, grass was remembered as more green, bricks more red, etc.

In a factor analysis study, Christal (1958) hypothesized and investigated nine factors which seemed to be related to memory ability. One factor labeled "visual imagery" was divided into three classifications: color, form, and position, Memory for elements in each classification was thought to be independent of the other two. One test was developed to check for a color factor in visual memory. The test design did not allow Ss the use of verbal associations. This test plus sixteen others was applied to analyze the nine factors. The Ss were 718 Air Force enlisted men.

> The resulting test scores were intercorrelated and a total of 12 centroid factors were extracted from the intercorrelation matrix. Eleven of these factors were rotated orthogonally. Of these four were identified as . . . memory factors (p. 23).

Christal, recognizing the difficulty in drawing conclusive evidence from one factor analysis study, concluded that "memory for color represents a special ability which is relatively independent of associative memory (p. 23)."

The Stroop Color-Word Test

Jensen and Rohwer (1966) described the original Stroop Color-Word test which contained three cards: ". . . a word card (W), a color card (C), and the incongruous color-word card (CW) (p. 37)." Stroop's Test used five colors: purple, brown, blue, red, and green. These colors, words, and the color-word combinations were arranged in a 10 x 10 matrix on separate cards. The Stroop phenomena is that it takes Ss more time to name colors than to read color names. Stroop's studied indicated that the phenomenon also occurred with common objects since Ss took more time to name common objects than to read the object's name. Several similar explanations for this phenomenon have been generated and are summarized by Jensen and Rohwer.

> The most common explanation is that of differences in amount of practice in color naming and word reading. . . . Adults do not spontaneously react to every object or color they see by giving its name, while the mere act of recognition of printed words implies a covert, if not overt, verbal response. Consequently the habit strength for responding verbally to printed words is presumed to be greater than the habit strength for verbally responding to objects and colors (p. 55 and 56).

Color-word interference occurred when the color-word differed from the color of the ink in which it was presented. With the (CW) card, Ss nearly always took twice as much time to name the ink's color than when the ink was presented in color patch form. Apparently the (CW) card provides "a conflict situation . . . due to response competition between habits of unequal strengths . . . (p. 59)"

Several variations of Stroop's original test have been made. One variation was constructed by Thurstone and is largely the standard form used today. In 1965, Jensen extracted color difficulty, interference, and speed factors from the Stroop device. These three factors accounted for 99 per cent of the variance.

Further in their review, Jensen and Rohwer discussed studies which related the Stroop test to age, sex, intelligence, and memory variables. The age variable indicated a trend somewhat inconsistent with the theory which traced interference to competition between unequal habits. It was expected that increased age would bring increased interference when, in fact, just the reverse occurred. Six differences were found in each study that compared the sexes and ". . . girls and women are better than boys and men at color naming. . . (p. 65)"

When aptitudes and mental ability were correlated with Stroop scores, little relationship to intelligence was found. "There is no reported instance of the Stroop ever having been used with Ss much below the normal range of intelligence, and most studies have used college students (p. 74)."

In summary,

> The evidence suggests that the Stroop scores share relatively little variance in common with the perceptual and personality spheres and evince most of their relevance in the cognitive realm (p. 88).

Klein (1964) used a Stroop Color-Word Test variation to determine the extent words interferred with certain color naming tasks. The meaningfulness of verbal materials in which colors were embedded was increased systemically. That is, six forms of the CW card were made up and could be classified as nonsense syllables, uncommon words, common words, words that bring thoughts of a given color, color names not used with the colored inks and finally the typical (CW) condition. Klein's concluding evidence indicated that interference with naming colors increased as word meaningfulness increased.

In studying the sources of interference effects, Schiller (1966) used a total of 240 Ss from grades 1, 2, 3, 5, 8, and 13. Each S read a list of forty color words which randomly contained the names of four colors then named the colors of forty color patches which were also arranged randomly. The Ss were assigned to one of four matched groups. Assignment was determined by performance speed. Each matched group was provided one of four different test cards, and the task for each group was to name the colors found on the card.

> On these cards words were printed in the colors red, blue, green, and yellow as follows: Card A: The words RED, BLUE, GREEN, and YELLOW were printed in incongruent combinations (i.e., the word red was printed in green color, etc.). Card B: The words TAN, PURPLE, GRAY, and BLACK. Card C: The words LEMON, FIRE, SKY, and GRASS in incongruent color combinations (i.e., lemon was never printed in yellow). Card D: The consonant syllables HJH, CVGJC, BHDR, GSXRQ. . . . The total reading time on each card was measured by means of a stop watch (p. 106).

Data analysis indicated that words were read faster than colors were named, and ". . . the extent of interference is minimal in 1st graders, becomes maximal in the 2nd and 3rd grades, and then declines gradually

(p. 105)." His interpretation of this finding differed from Klein's views in that Schiller believed possibly

> . . . words provide a more efficient medium for coding than colors. This might be so because printed words have greater redundancy. Each letter, parts of letters, and parts of words can provide the same or related information. The number of letters in a word might also serve as an important selective cue. Simultaneous processing of these cues could result in eliciting the correct response in minimal time. A color strip, by contrast, carries less information and thus takes a longer time to process (p. 107).

Ziek and Weiss (1968) also studied how words interfere with the "color-naming response." Their experiment, designed to replicate Klein's earlier work, required the Ss to identify the colors presented on five different lists of colored material. The time required for Ss to complete a list was used to check color-word interference.

> The five lists were (A) a color list, (B) a low meaningful nonsense syllable list, (C) a high meaningful nonsense syllable list, (D) a list of common English verbs, and (E) a 'standard' color-word interference list. The color list (A) was used to measure the speed of color recognition. . . . Color-word combinations on lists B, C, and D were randomly arranged with the restriction that no word be accidentally associated systematically with any particular colors. List E, the color-word interference list consisted of the names of the six ink colors--blue, red, green, brown, black, purple--with the color names never correctly corresponding to the ink color in which they were printed (p. 3).

Their results, which support Klein's findings, indicated ". . . a significant positive relationship between the meaningfulness of words that compose a color-word list and the difficulty in identification of the color in which the words were printed (p. 6)." Interference becomes more pronounced as the words in which colors are embedded become more meaningful.

The Effects of Verbal Cues and Color Codability

Kanner (1968) both investigated and reviewed the use of color in instructional materials and its effects upon learners. Findings discussed in his literature review indicated that brightness and contrast may have more of an effect on visibility of materials than color. In some studies, color coding was used extensively with serial learning.

> A consistent finding is that as the number of color coded items increases, the value of color as a cue for selecting important information decreases. As the total number of items decreases, the value of color decreases. In other words, in a very dense visual display color coding at some minimal level helps in picking out important information, but if you increase this use of color its value as a selection cue diminishes (p. 1 and 2).

In 1959, Kanner did two studies which compared the teaching effectiveness of monochrome television and color television. In both studies, two groups were matched for aptitude, and each received the same stimulus presentation except that one group saw it in black-and-white and the other group saw it in color. Multiple choice tests administered immediately after the presentations were analyzed and ". . . no significant differences were found between groups receiving instruction by color or black and white television (p. 4)." He attempted to explain why color has little effect on learning by suggesting that color effects on learners are intimately related

> . . . to the ability of the learner to use verbal cues or labels as substitutes for color. Just as we can handle the concepts of table, chair, or hat by the use of words, so I believe words or labels can be substituted for the actual perception of color by the learner (p. 5).

The findings of Kanner and others are consistent with the Whorfian hypothesis which indicated that thinking is influenced substantially by the language in which it is conducted. Whorf (1956) states that "we dissect nature along lines laid down by our native languages (p. 212)." In other words, the language used in a culture shapes the cognitive activity of group members. Language is thus seen as a common or shared coding system with recognition, discrimination, and identification of objects and events all affected by the system.

Brown and Lenneberg's (1954) results lent other support to the Whorfian view and hypothesis. They showed that the length of a color's name is ". . . correlated with the latency of naming response and the reliability of the response from person to person within the linguistic community and from time to time in one person (p. 462)." Codability was the only general factor found in a factor analysis of their measures, and the codability of a color was shown to be related to Ss' performance in recalling the color.

Their measurement of color codability was developed by the following method. The highest chroma colors from the Munsell series were mounted on cards. Then from the 240 colors presented, 5 judges were asked to select the best red, orange, yellow, green, blue, purple, pink, and brown since these 8 English color names are used most frequently. Judges were highly consistent in their color chip selection, and from the 240 Munsell colors, there seemed to be 1 color chip that best represented each of the 8 basic color names. These names were then compiled into a test list. Sixteen additional chips were added to the test list resulting in a balanced representation of 24 colors around the Munsell chroma wheel.

Two sets of the 24 color chips were mounted on cards. The first set contained 24 cards with 1 color chip per card while the other set was mounted on a larger, single card.

English was the native language of the 24 college students selected as Ss for this study. They were screened for color blindness with the Pseudo-Isochromatic Plates. Following screening, the Ss worked with tasks involving various delays and complications. The tasks required each S to view independently the full chart of 24 colors for approximately five minutes. Then each S was required to view the individual color chips.

> To expose the single small cards a drop shutter was mounted in a 3 x 2-foot gray (Munsell neutral value 6, reflectance 30 per cent) board. The board was about three feet from the subject's (S's) eyes and was illuminated from above and behind by a General Electric standard daylight fluorescent lamp (p. 458-9).

The Ss were then asked to name each color chip as it appeared.

> 'Name' was defined as the word or words one would ordinarily use to describe the color to a friend. The Ss were urged to be both quick and accurate (p. 459).

The Ss were timed by a stop watch and were allowed to view each color until they said a color name. For all colors, the mean reaction time was found ". . . by ranking all of the reaction times of an individual S and taking the mean rank across Ss for every color (p. 459)." As a result each color was assigned a codability score and rank. As the task became more complicated, the importance of the storage factor increased, and codability accounted for more variance in task performances.

Summary of Related Research and Literature

The color research literature indicated that we are left with a variety of major questions that have been left unanswered. How severe are learner's limitations in using color cues from instructional materials? Do differences exist among individuals in their use of color representations from short-term or long-term memory? Do the commonly accepted verbal labels or codes for colors affect individuals differently? If so, what are the differences among codable and non-codable colors? Are color cues of greater value (i.e., more utilizable) in some stimulus conditions than in others? How do individuals use or process color cues to assist in learning from instructional materials? What special abilities, priorities, or strategies do they employ? How is color information recoded? Does the addition of color have motivational effects? If so, under what range of conditions? To what extent does the addition of color help attract attention, and what limits are there on such effects?

In summary then, limited experimental research on color memory effects in instructional materials is provided in the relevant literature. Based on the evidence, it is reasonable to say that people may reveal distinct limitations as they try to utilize color cues in learning.

METHODS AND PROCEDURES

Experimental Methods

In an experimental study, the researcher must make a decision concerning what conditions will be isolated and examined. Generally, those variables that hold some importance to the investigator and seem to affect the process directly are identified, isolated from other variables which may bias the interpretations, and studied. Five such variables or factors were identified and selected for testing through the motion-picture film medium. They seemed most relevant to instructional practice, and they also were feasible for consideration in a single study.

Factors Studied. The five factors selected for study were labeled verbal cueing, prompting, type of question, stimulus silhouettes, and color codability. The differences between the two levels of Factor A or verbal cueing were represented by Film A and Film B. Individuals who viewed Film A or Level 1 of Factor A responded to color questions by selecting the appropriate color name from a 2 x 4 array of color names. Individuals who viewed Film B or Level 2 of Factor A responded to color questionsby attempting to select a color patch from a 2 x 4 array which matched the color of the stimulus object or shape. The differences between the two films existed only for the color test items. Both Film A and Film B contained two levels of Factor B which is referred to as prompting. Level 1, audio prompting, was applied to half of the stimulus scenes. The other half of the stimulus scenes, designated Level 2, did not provide audio prompting. Factor C specified the type of question asked. Level 1 denoted 160 color questions while Level 2 referred to 160 position questions. For a position question, an individual was required to choose one of four possible locations in order to make a correct response; while for a color question, he selected one of eight colors displayed. Position test items were identical for both Film A and Film B. The stimulus silhouettes or figures constituted Factor D. These were arbitrarily divided into two levels. Level 1 consisted of objects: dog, key, bird, umbrella, and truck; while Level 2 contained five geometric shapes: square, star, circle, diamond, and triangle. Color codability was labeled Factor E. Level 1 contained four high codable colors and Level 2 four low codable colors which were selected from the Brown and Lenneberg study.

Randomization Process. All stimulus scenes or treatment conditions were randomized to control for practice, fatigue, and other effects. While randomization may not eliminate these effects, it assumes that they will not become systematic and confounded with treatment conditions. Thus, carry over effects which could arise from one treatment condition to another were controlled through the randomization process, and the same random order of stimulus presentation was identical for all Ss.

Conditions that were randomized included prompting, position or color testing, the color specified for the object used as a correct stimulus, the object used as a correct stimulus, the objects selected as distractors, the colors of the distractor objects, correct stimulus location, and the location of distractor objects. The various conditions specified for each scene were determined by the following method.

An arbitrary coding system was devised to designate all the possible conditions that would be involved in the randomization procedure; i.e., the prompting factor was assigned the letter B with audio prompting being Level 1 and no prompting being Level 2; type of question asked was Factor C with color as Level 1 and position as Level 2; stimulus figures were Factor D with simple objects 1 through 4, Level 1 and geometric shapes 6 through 10, Level 2; Color codability was Factor E with high codable colors 1 through 4, Level 1 and low codable colors 5 through 8, Level 2. Given code letters and numbers such as $B_1C_2D_4E_6$, one could determine the components of any given treatment condition. In order to randomize any given treatment condition, the exact number of coded cards necessary was prepared for each level of every factor. Since there were 10 objects, each object would have 32 cards and each could be used 32 times as a correct stimulus object; i.e., 10 x 32 = 320. Since there were 8 colors, each color would have 40 cards and each could be used 40 times as a correct stimulus color; i.e., 8 x 40 = 320.

A typical treatment condition was built in the following randomization manner. Cards for prompting conditions, question type, correct stimulus object, and correct stimulus color were drawn <u>independently</u> from a box. First, the correct stimulus object cards were removed randomly and recorded for each item. The same procedure was then applied to colors. Selected stimulus object cards and color cards were <u>not</u> returned to the drawing box thus allowing each object and color to appear only a given number of times as the correct stimulus. An additional constraint prevented the same object or color from being used sequentially as a correct stimulus.

Once all correct object cards had been removed, they were returned to the box for distractor object selection as outlined by the randomization procedure. The selection of colors followed the same procedure. Each object appeared randomly 96 times as a distractor throughout the 320 items; while similarily, each color appeared 120 times as a distractor.

Prompting conditions for each item also were determined independently by randomly selecting a card from 160 prompt cards and 160 no prompt cards. Selected prompt or no prompt cards also were not returned to the drawing box. A somewhat similar procedure was used to determine the type of question asked; i.e., 160 cards were labeled color, and 160 were labeled position then one card was selected randomly for each of the 320 items.

Thus, the research design, as outlined in FIGURE 1, specified the procedures for producing two 16mm motion-picture films which will be referred to as Color Memory Study A and Color Memory Study B. Each color memory testing film included the five variables or factors in a format resembling both an educational film and a test.

The Statistical Design. The statistical design used in this study is also illustrated by FIGURE 1. This design, a multi-factor analysis of variance with repeated measures, is outlined by Winer in Statistical Principles in Experimental Design (1962, pp. 319-324). The design is such that comparisons between treatment conditions at either level of Factor A involved random differences between groups of Ss plus systematic differences related to Factor A. However, the main effects of Factors B, C, D, and E as well as all interactions are free of random differences between groups of Ss. The reduced error variance inherent in this design provided greater possibility for detecting small or subtle differences on these factors; i.e., the computed F-ratios generally constitute more sensitive or powerful tests of the hypotheses. Thus, the effect on color memory as a function of the effect of Factors B, C, D, and E was determined for each S since he received all treatment conditions. Two additional advantages also help explain the selection and use of a repeated-measures design. First, this design permits an efficient use of Ss, and second, in this research, order effects probably would be small when compared to the treatment effects.

Factors A, B, C, D, and E are assumed to be fixed since the levels were selected by a systematic or non-random procedure. In this research, the main effects systematically checked differences between the two levels of each factor. In addition to differences which may be attributed to main effects, the interactions reflect differences between effects resulting from unique results of combinations of various levels within factors. The ANOVA design is presented in TABLE 1.

The total variation in criterion performance could be separated into the two components, between and within subject variation. Thus, since certain error terms used for the appropriate F-tests required the pooling or combining of variance from the two groups, homogeneity of variance was checked by using an F-max test as described by Winer (1962, pp. 92-96). This statistic was used to test the hypothesis that:

$$\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \ldots \sigma_k^2$$

		Prompt B_1								Non Prompt B_2							
		Color C_1				Position C_2				Color C_1				Position C_2			
		Simple Objects D_1		Geometric Shapes D_2		Simple Objects D_1		Geometric Shapes D_2		Simple Objects D_1		Geometric Shapes D_2		Simple Objects D_1		Geometric Shapes D_2	
		HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2
A_1 Film A	Ss 1 … 43	G_1															
A_2 Film B	Ss 1 … 43	G_2															

FIGURE 1

STATISTICAL RESEARCH DESIGN

This statistic has the form: $F\ max = \frac{\text{largest of k treatment variances}}{\text{smallest of K treatment variances}}$ with k(n-1) degrees of freedom, where k equals 32 treatment conditions.

The items in each film were arranged randomly under the 16 unique treatment conditions as specified in APPENDIX A. Due to the randomization procedure used for each factor and level element, the unique treatment conditions did not consistently appear 20 times. Randomization of the 16 unique treatment combinations found in each film, created 4 treatment conditions to which Ss responded 21 times, 4 treatment conditions to which Ss responded 19 times, and finally, 8 treatment conditions on which measures were taken 20 times. This made the potential number of correct responses unequal for the various unique treatment conditions and thus made Ss' performances on each type of item somewhat incomparable. Therefore, the harmonic mean was used due to the unequal occurance of several treatment item combinations. The harmonic mean n as defined by Winer (1962, p. 223) is

$$\tilde{n} = \frac{k}{(1/n_1) + (1/n_2) + \ . \ . \ . + (1/n_k)}$$

Because of the multiple choice format used in the criteria in this research, chance responding by Ss possible might bias the findings. For example, the 160 position items of the 320 total items required each S to select 1 alternative from 4 possible alternatives. By chance alone each S probably could get one-fourth of the 160 position items correct, or 40 items. An additional 160 items which tested for color of the 320 total items required each Ss to select 1 alternative from a total of 8 possible alternatives. By chance alone each S could get one-eighth of the color items correct, or 20 items.

TABLE 1

SUMMARY OF ANALYSIS OF VARIANCE

Source of Variation	Sums of Squares	df	Mean Squares	F ratio
Between subjects				
A				
Subj w. groups				
Within subjects				
B				
AB				
B x subj w. groups				
C				
AC				
C x subj w. groups				
D				
AD				
D x subj w. groups				
E				
AE				
E x subj w. groups				
BC				
ABC				
BC x subj w. groups				
BD				
ABD				
BD x subj w. groups				
CD				
ACD				

TABLE 1 (continued)

Source of Variation	Sums of Squares	df	Mean Squares	F ratio
CD x subj w. groups				
BE				
ABE				
BE x subj w. groups				
CE				
ACE				
CE x subj w. groups				
DE				
ADE				
DE x subj w. groups				
BCD				
ABCD				
BCD x subj w. groups				
BCE				
ABCE				
BCE x subj w. groups				
BDE				
ABDE				
BDE x subj w. groups				
CDE				
ACDE				
CDE x subj w. groups				
BCDE				
ABCDE				
BCDE x subj w. groups				

Therefore, to prevent a chance bias in the data, a correction for guessing was applied. This formula as outlined by Downie and Heath (1965, p. 229) is:

$$\text{Score} = R - \frac{W}{K-1}$$

where $\underline{R}$ = the number of right answers on a student's paper
$\underline{W}$ = the number of wrong answers on a student's paper
$\underline{k}$ = the number of possible choices in the test item.

Procedures

Stimulus information may be transmitted through a variety of communication channels. One such transmission channel, or medium, is the motion-picture film. It provides several advantages for experimental testing. Seibert and Snow (1965) have described different cinematographic techniques that may be used in motion-picture film testing. They are:

> Live Action (LA), in which real events and environments are recorded on film; Simulated Live Action (SL), in which working models, mockups, etc. are used to represent and give the illusion of live action events; Animation (AN), where single frames of objects or of drawings are shot as still photographs but their synthesis on the screen gives the illusion of smooth motion or mobility; Serial Still (SS) presentations which, while photographed in a manner similar to AN, maintain a discrete, list-like structure on the screen (p. 26).

The motion-picture film medium was selected for use in the present color memory study for reasons identified by Seibert and Snow. First, the motion-picture can realistically visualize materials through carefully planned photography. The sequential characteristics of the motion-picture medium allow precise investigation of color information processing by controlling the critical timing requirements of stimulus and response scenes. Also, film seems to be a natural medium especially when one considers the vast number of films used for instructional purposes. In testing, film helps standardize the test by alloting equal time for each item. It helps assure that instructions will be identical across all groups and that experimental items may be administered to larger groups. Finally, and above all, film producers often use expensive color in instructional motion-pictures because they claim that color provides understanding, assists learning, and increases aesthetic appreciation of their product.

Color Test Development. As indicated earlier, this color study is based, in part, upon the work of Brown and Lenneberg (1954). Their color codability study provided the basis for selecting colors included in the present study.

Eight colors were selected from the 24 ranked colors included in the Brown and Lenneberg color codability study. The four colors with the shortest mean reaction time were picked for the high codable color level while the four colors with the longest mean reaction time were selected for the low codable color level. The four high codable colors selected have Munsell designations as follows: 2.5YR 6/14, 5YR 3/4, 5Y 8/12, and 5PB 4/10; while the four low codable colors are: 7.5Y 6/8, 2.5Y 7/10, 5RP 6/10, and 7.5R 8/4. All eight colors were purchased from the Munsell Color Company, and each color was on a 6" x 10" Glossy Finish Sheet. Each color sheet duplicated as accurately as possible one of the eight colors selected from Brown and Lenneberg's codability study.

Guidelines were established for producing the two 16mm motion-picture films. These planning activities were then arranged into a storyboard which was used as a guide to film all scenes. The storyboard specified background, item number, objects with colors and their locations, stimulus or test scene, color or position testing, appropriate audio, and frame count for each scene. A sample storyboard sheet is presented in APPENDIX B.

Each film contained many brief scenes with each scene using one of five standard backgrounds or landscapes. For convenience, each background was given a simple name: Desert Cactus, Natural Arch, Winding River, Winter Scene, and Bay Bridge. In addition to the five standard backgrounds, ten different and appropriately-sized figure silhouettes were designed as stimulus materials to be placed on the backgrounds. All ten silhouettes were reproduced in each of the eight colors for a total of eighty figures. For each stimulus scene, four differently colored figures were presented in one of four distinct locations: A, B, C, and D as shown in FIGURE 2.

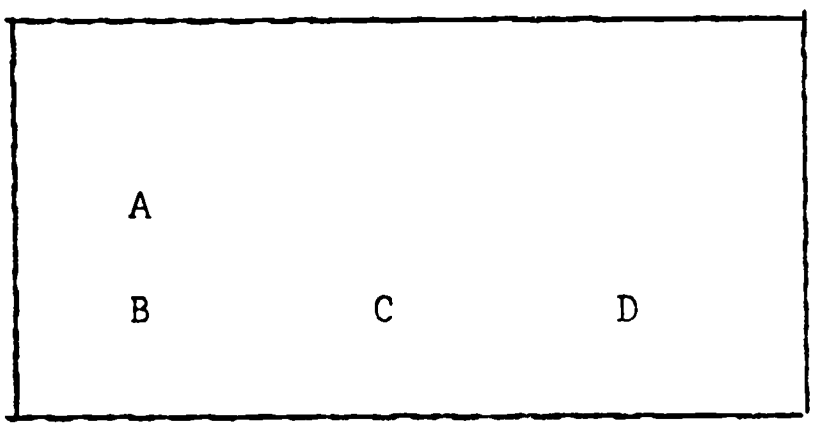


FIGURE 2

STIMULUS FIGURE LOCATIONS

Each film contained 320 items with each item being presented in 2 parts. The first part of an item was a stimulus scene which lasted for two seconds. Each stimulus scene had a narrow horizontal black band with the appropriate item number printed above it. This covered approximately the upper one-sixth of a background. Four differently colored figures then were placed in the designated locations on the background. Audio prompting, where specified, was applied to the sound track of the stimulus scenes. Whenever a stimulus scene appeared, the Ss could be prompted to notice the color or location of a figure. For example, the audio track might say, "Note the diamond's color," or "Note the truck's position." After the stimulus scene ended, two other scenes appeared with the first testing for earlier information and the second presenting new stimulus information. For example, Item 10 Stimulus would be followed by Item 9 Test, then Item 11 Stimulus followed by Item 10 Test, then Item 12 Stimulus followed by Item 11 Test, and Item 13 Stimulus followed by Item 12 Test, and so forth. Exactly ten seconds after each stimulus scene, its appropriate test scene appeared. The test scene had the same item number at the top but no black band. It used the same background as used on the stimulus, however, it remained on the screen for eight seconds. The possible answers to the question in the test scene were superimposed over the background, and a verbal question was asked. The question tied the stimulus scene to the test scene. For example, the audio track might ask, "In Desert Cactus, the position of the diamond was?" or "In Bay Bridge, the color of the bird was?"

As stated previously, many of the conditions for each scene entered the storyboard by a random or forced randomization procedure. However, certain systematic conditions were applied to each stimulus and test scene to assist Ss in responding. The backgrounds were designed to be distinctive, and each was given a verbal label or name early in the filmed instructions. The five backgrounds for either stimulus or test scenes always appeared in this predetermined order: Desert Cactus, Natural Arch, Winding River, Winter Scene, and Bay Bridge. In addition, a background that appeared with a given stimulus item always appeared with the test scene of that item.

The item numbers appeared in the consistent order 1 through 320. An identical item number was used to link each test scene with the appropriate stimulus scene. As described earlier, all stimulus scenes had a narrow black band just below the item number, but test scenes did not have this black band.

The frame count and timing also were consistent: for stimulus scenes, 48 frames equaled 2 seconds, for test scenes 192 frames equaled 8 seconds. A total of 53 1/3 minutes of color film was used in each film to present all 320 items.

The color names used in the test scenes of Film A were selected by a group of 34 judges. Each judge was asked, individually, to determine appropriate names for each of the eight color chips displayed on a white poster board. They were asked to record their 1st, 2nd, and 3rd choices for each chip. A sample recording sheet is located in APPENDIX C. There was high agreement among judges for seven of the eight colors; for example, Color A received 22 votes for yellow, 1 for mustard, 1 for bright yellow, etc. Names selected by the judges for each color chip are listed by ranking in APPENDIX D. Then, the color name receiving the highest ranking was selected and used in the test scenes of Film A. These color names appear with their Munsell notations in APPENDIX E.

Each film was planned to be a packaged, self-contained experimental session and the screening was to provide raw data from each group all in the space of little more than an hour and a half.

Film Production. The Audio Visual Production Department of Purdue University provided the Oxberry Animation Camera and Stand for the filming. With this equipment, the number of frames or timing required for each scene can be filmed accurately.

Three short, pilot films were made to determine appropriate lighting, f-stop setting, stimulus and test scene lengths, and other considerations such as the time span to include between a stimulus and test scene.

The actual filming of the stimulus and test scenes was done at a height of 2568 as measured by the Oxberry elevation counter which corresponds to an Oxberry ten field. Before each filming session, the lamps were adjusted to a 500 reading on the Sckonik light meter. Then the lamps were checked every hour for a possible drop in light intensity. The camera f-stop was always set at f.8 with the dissolve control at full open. The f.8 stop seemed to provide the best compromise for color saturation and contrast. Before the shooting of each scene, the Oxberry frame counter was reset to provide the exact timing.

The original film stock used was Ektachrome Commercial Type 7255. The same stock number was used for all scenes except the instructions and approximately 40 items in Film B which had to be retaken.

Other variables that could affect filming were controlled as much as possible. The same camera lens, focal length, lamp type, and general equipment were used throughout the filming process. Also, the temperature and humidity of the filming room were controlled.

The Recording Studio of Audio Visual Production Department was used to record the sound. The audio track was prerecorded on magnetic tape and transferred to magnetic film. After the original color film had been processed, the magnetic film was edited to the original film footage thus placing each audio statement in its proper location. Normally, all editing is done with a "work print," however, since the color picture needed relatively little editing and the audio track did not require "lip synchronization," audio editing was made directly to the original film stock.

Planning, pilot work, and editing to original film stock greatly reduced the expenses normally incurred in color film production. All of the original film, when processed, had deeper saturation and more contrast than the original Munsell color chips. This was according to plan since a film print generally is lighter than the original film stock. The first film print, reproduced from the original film stock, was lighter in color and closely matched the original color chips. Deluxe General Inc., the film processing company, provided the accept-able first print which was done on Color Reversal Type 7387 Film. It was used as the experimental treatment condition for this study.

The Sample. The Ss used in the pilot and experimental sessions were male and female Education and Introductory Psychology students. The first pilot session consisted of 33 male and female junior and senior students who were enrolled in an Introductory Audio Visual Education Course. This pilot run revealed a major flaw in the design of the filmed color test and test booklet. The Ss could, with the test booklet designed for the study, respond ahead of time to any prompted item well before the appropriate test scene for that item appeared on the screen. Thus, a decision was made to run the first two of the four experimental sessions as additional pilot studies in an effort to determine how this flaw could be controlled and also to standardize the instructions. The randomly assigned Ss used in the last two pilot sessions were 108 male and female Introductory Psychology students. The final two pilot sessions revealed that shields should be developed and used for the two upcoming experimental sessions. The 5" x 7" shields which concealed upcoming test items would not give Ss an opportunity to respond ahead of time and would force the Ss to keep pace with the film. A center slot permitted responses just to the question that appeared on the screen. The Ss in the two Experimental Sessions were told that the shields would prevent them from losing their places in the test booklets.

All Ss in both the pilot and experimental sessions were screened for color blindness with the Pseudo-Isochromatic Color Plates. The color blind Ss were rejected, however, they were allowed to take the test and later their data were dropped from the experimental study.

The Introductory Psychology male and female students who voluntarily took part in the two experimental sessions were in the experiment to fulfill a course requirement. They were randomly assigned to one of the two experimental sessions. Each S was required to respond to the information presented in each stimulus array. The data from 86 Ss, 43 in each experimental session, were used for analysis work.

The Experimental Sessions. An Audio-Visual Center auditorium, Room 57, which seats 99 people was used as a viewing room for all sessions. An attempt was made to control important viewing variables within that room. Before the start of each session the rheostat lights were lowered to one foot candle as measured by the Photovolt Model 200 A Light Metering System. This measurement was taken from the center of the room.

A General Electric CYS 1200 watt projection lamp and a Bell and Howell, Model 550, Filmsound Specialist Projector were used to screen the films for all sessions.

As the burning time of a projection lamp lengthens, the possibility of a light intensity drop increases. This could cause a color shift to occur on the screen. Because of this, the projection lamp was replaced at the start of each experimental session.

A permanently mounted Linticular screen was used for all sessions. A Linticular screen is ideal for an auditorium the size of Room 57.

The Ss were assigned to specific seats in Room 57 and were spaced one seat apart. The temperature and humidity in the room were controlled automatically and variation from session to session was minimal.

The coversheet plus the first page of the response sheets for both Films A and B are shown in APPENDIX F. The response sheets were designed to be simple to use. Adequate space was provided between items, and generally the same number of items appeared in each column of each sheet.

Before the filmed instructions were shown in each session, the Ss received the following description of the study. "The purpose of this study is to examine how individuals are affected by and will remember color and location information in instructional materials." The Ss were then informed that the film was difficult and they must concentrate on each stimulus item. Following this brief introduction, the filmed instructions were shown. The instructions explained the backgrounds, objects, color, prompts, audio questioning and timing procedures. As nearly as possible, all Ss received identical instructions. Following the pilot runs, the verbal instructions and procedures were set up in "check list" form and followed for each experimental session. However, Films A and B used separate filmed instructions. In Film A, each color was labeled, and the names were discussed in the filmed instructions. The Ss who viewed Film B were required to respond to color patches not names, therefore, Film B instructions did not mention color names. Other than this exception, the verbal and visual instructions to all experimental Ss were the same. Then, the instructions were followed by ten example items. After the filmed instructions and example items, all experimental Ss received final verbal instructions. These are listed in APPENDIX G.

RESULTS

The criterion variable used throughout this study was the adjusted-mean number of stimulus items within a treatment condition to which a S responded correctly. In this study, a S had to respond to questions which required the recall of either a stimulus color or a stimulus position location that previously had been encountered in a stimulus or information scene. The nature of the item, color or position, was made known by the audio portion of the response scene.

The data collected were statistically analyzed in terms of the five predicted hypotheses established for the research. After due consideration of the purely exploratory nature of this research, it was decided a priori that the .05 level of confidence would be used for the tests of the five null hypotheses. However, when a main effect or an interaction was significant at the .01 level of confidence, it is so noted.

As stated in The Statistical Design, a multi-factor analysis of variance with repeated measures on each subject was selected to analyze the data. One of the assumptions underlying this analysis was the homogeneity of variance. For the ANOVA in this research, certain specified parts of the within subject variation were used as the denominators for appropriate F-ratios. Since the error terms used required the pooling or combining of variance from two groups, homogeneity of variance was checked. TABLE 2 is used to show the treatment of this data. The hypothesis tested was that

$\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \ldots \sigma_k^2$, where k equaled the 32 treatment conditions.

TABLE 2

THE F-MAX TESTS

Results of F-max tests of homogeneity of variance on components that were pooled to form error terms used in ANOVA.

General Formula (Subjects within group pooling):

$$F_{max} = \frac{\text{Maximum (SS subjects within Group i)}}{\text{Minimum (SS subjects within Group i)}}$$

$$F_{max} = \frac{5497.44}{4754.91} = 1.16 \text{ (n.s.)*}$$

$^{*}F_{max}$ .99 (2.42) = 1.96

General Formula (Treatment by subjects within group pooling):

$$F_{max} = \frac{\text{Maximum } (SS_A \text{ x subjects within Group i})}{\text{Minimum } (SS_A \text{ x subjects within Group i})}$$

1. B x subjects within Groups. $F_{max} = \frac{1025.27}{833.54} = 1.23$ (n.s.)*
2. C x subjects within Groups. $F_{max} = \frac{298.70}{281.65} = 1.06$ (n.s.)
3. D x subjects within Groups. $F_{max} = \frac{189.66}{173.61} = 1.09$ (n.s.)
4. E x subjects within Groups. $F_{max} = \frac{147.19}{145.94} = 1.01$ (n.s.)
5. BC x subjects within Groups. $F_{max} = \frac{296.41}{245.74} = 1.21$ (n.s.)
6. BD x subjects within Groups. $F_{max} = \frac{244.71}{170.19} = 1.44$ (n.s.)
7. CD x subjects within Groups. $F_{max} = \frac{167.91}{142.41} = 1.18$ (n.s.)
8. BE x subjects within Groups. $F_{max} = \frac{229.52}{165.63} = 1.39$ (n.s.)
9. CB x subjects within Groups. $F_{max} = \frac{192.96}{100.46} = 1.92$ (n.s.)
10. DE x subjects within Groups. $F_{max} = \frac{142.97}{141.11} = 1.01$ (n.s.)

$^{*}F_{max}$ .99 (2.42) = 1.96

TABLE 2 (continued)

11.	BCD x subjects within Groups.	$F_{max} = \frac{197.61}{116.90} = 1.69$	(n.s.)*
12.	BCE x subjects within Groups.	$F_{max} = \frac{247.01}{168.42} = 1.47$	(n.s.)
13.	BDE x subjects within Groups.	$F_{max} = \frac{213.86}{135.80} = 1.58$	(n.s.)
14.	CDE x subjects within Groups.	$F_{max} = \frac{145.94}{137.31} = 1.06$	(n.s.)
15.	BCDE x subjects within Groups.	$F_{max} = \frac{207.52}{158.69} = 1.31$	(n.s.)

*F_{max} .99 (2.42) = 1.96

As is shown in TABLE 2, this hypothesis was not rejected. Thus, the assumption of homogeneity of variance was reasonable and the assumption was made that the corresponding variations were equal.

The harmonic mean was computed and is 20. The computational work is presented in APPENDIX H.

Before the data were subjected to analysis, they were adjusted by correcting for guessing. As indicated earlier, the color item questions had eight possible alternatives while position items only had four possible alternatives, thus biasing of the data, due to chance responding (guessing) could affect systematically an individual's score, yielding more position items correct. TABLE 3 is used to show the basic ANOVA statistical design plus the pre-adjusted-means and the means which were adjusted by the correction formula. The adjusted-means were used in the ANOVA.

Results of the Predicted Hypotheses

The ANOVA summarized in TABLE 4 utilized Ss' adjusted-mean correct responses for each of the treatment conditions outlined in TABLE 3. The F-ratios reported in the ANOVA summary were used to test the five null hypotheses. As the data presented indicated, four of the five main effects and several interactions were significant. The four significant main effects were color codability, topic or information tested, stimulus meaningfulness, and prompting factors. Each level within these four significant factors plus the significant interactions were inspected to locate the direction and nature of these differences.

TABLE 3

STATISTICAL RESEARCH DESIGN AND MEANS

		Prompt B_1									Non Prompt B_2							
		Color C_1				Position C_2					Color C_1				Position C_2			
		Simple Objects D_1		Geometric Shapes D_2		Simple Objects D_1		Geometric Shapes D_2			Simple Objects D_1		Geometric Shapes D_2		Simple Objects D_1		Geometric Shapes D_2	
		HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2		HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2	HC E_1	LC E_2
pre-adjusted-means A_1	Ss 1	17.3	14.2	14.6	13.3	16.7	18.3	18.2	16.3	G_1	4.0	3.0	3.2	3.1	6.4	5.6	5.9	4.7
adjusted-means	43	16.8	13.7	14.1	12.3	16.1	17.4	17.2	15.1		2.1	1.3	1.4	1.0	2.5	1.6	1.7	1.0
pre-adjusted-means A_2	Ss 1	16.0	14.2	12.9	13.7	15.8	16.7	17.0	15.7	G_2	5.0	3.9	3.0	3.5	6.8	6.2	6.6	4.4
adjusted-means	43	15.3	13.5	12.0	12.8	14.8	15.2	15.9	14.3		3.0	1.3	1.2	1.4	2.7	2.1	2.4	1.0

Factor E tested the first null hypothesis and based on the data, it was rejected. There were relevant and significant differences between Ss' average performance on high codable colors as compared to low codable colors. As indicated in the table, performance on items testing Level 1 or high codable colors differed significantly from Level 2 or low codable colors. It was indicated in this result that stimulus materials presented in high codable colors were remembered better than stimulus materials which appeared in low codable colors.

The second null hypothesis was tested by Factor A, the verbal cueing factor, and it was found to be nonsignificant. There were no major differences between the average performance of Ss who viewed Film A when compared to Ss who viewed Film B. Thus, Factor A revealed no significant difference in learning between the two methods of color questioning used in this study. For each Film Level, the stimulus and test conditions were presented via the same mode.

A test was made on the third null hypothesis or Factor C. This test checked differences between Ss' average performance on color items as compared to position items. Significant differences were found between the two stimulus topic levels tested in Films A and B. Thus, the third null hypothesis was rejected. The evidence seemed to support the notion that position information is processed and remembered more than color information.

The stimulus shape or form factor, labeled Factor D, was tested. This was a test of the fourth null hypothesis of no difference between Ss' average performance on simple objects as compared to geometric shapes. As indicated in TABLE 4, Level 1, simple objects,

TABLE 4

SUMMARY OF ANALYSIS OF VARIANCE

Source of Variation	Sums of Squares	df	Mean Squares	F ratio
Between subjects				
A	55.8	1	55.8	1.5
Subj w. groups	3187.7	84	37.9	
Within subjects				
B	58513.6	1	58513.6	2644.2**
AB	189.8	1	189.8	8.6**
B x subj w. groups	1858.8	84	22.1	
C	423.1	1	423.1	61.2**
AC	5.3	1	5.3	.8
C x subj w. groups	580.3	84	6.9	
D	285.7	1	285.7	66.1**
AD	1.2	1	1.2	.3
D x subj w. groups	363.3	84	4.3	
E	278.5	1	278.5	79.8**
AE	12.1	1	12.1	3.5
E x subj w. groups	293.1	84	3.5	
BC	235.3	1	235.3	36.5**
ABC	11.0	1	11.0	1.7
BC x subj w. groups	542.2	84	6.5	
BD	17.9	1	17.9	3.6
ABD	7.1	[illegible]	7.1	1.4
BD x subj w. groups	414.9	84	4.9	
CD	65.8	1	65.8	17.8**
ACD	4.8	1	4.8	1.3

TABLE 4 (continued)

Source of Variation	Sums of Squares	df	Mean Squares	F ratio
CD x subj w. groups	310.3	84	3.7	
BE	2.0	1	2.0	.4
ABE	21.3	1	21.3	4.5*
BE x subj w. groups	395.1	84	4.7	
CE	12.1	1	12.1	3.5
ACE	25.4	1	25.4	7.3**
CE x subj w. groups	293.4	84	3.5	
DE	0.0	1	0.0	0.0
ADE	14.9	1	14.9	4.4*
DE x subj w. groups	284.1	84	3.4	
BCD	70.3	1	70.3	18.8**
ABCD	.4	1	.4	.1
BCD x subj w. groups	314.5	84	3.7	
BCE	29.9	1	29.9	6.1*
ABCE	23.8	1	23.8	4.8*
BCE x subj w. groups	415.4	84	4.9	
BDE	13.2	1	13.2	2.1
ABDE	6.3	1	6.3	1.5
BDE x subj w. groups	349.7	84	4.2	
CDE	206.5	1	206.5	61.2**
ACDE	7.4	1	7.4	2.2
CDE x subj w. groups	283.3	84	3.4	
BCDE	53.4	1	53.4	12.2*
ABCDE	11.4	1	11.4	2.6
BCDE x subj w. groups	366.2	84	4.4	

LIST OF TABLES

TABLE 4 (continued)

* = Significant at .05 Level of Confidence

** = Significant at .01 Level of Confidence

TABLE 4 (continued)

* = Significant at .05 Level of Confidence

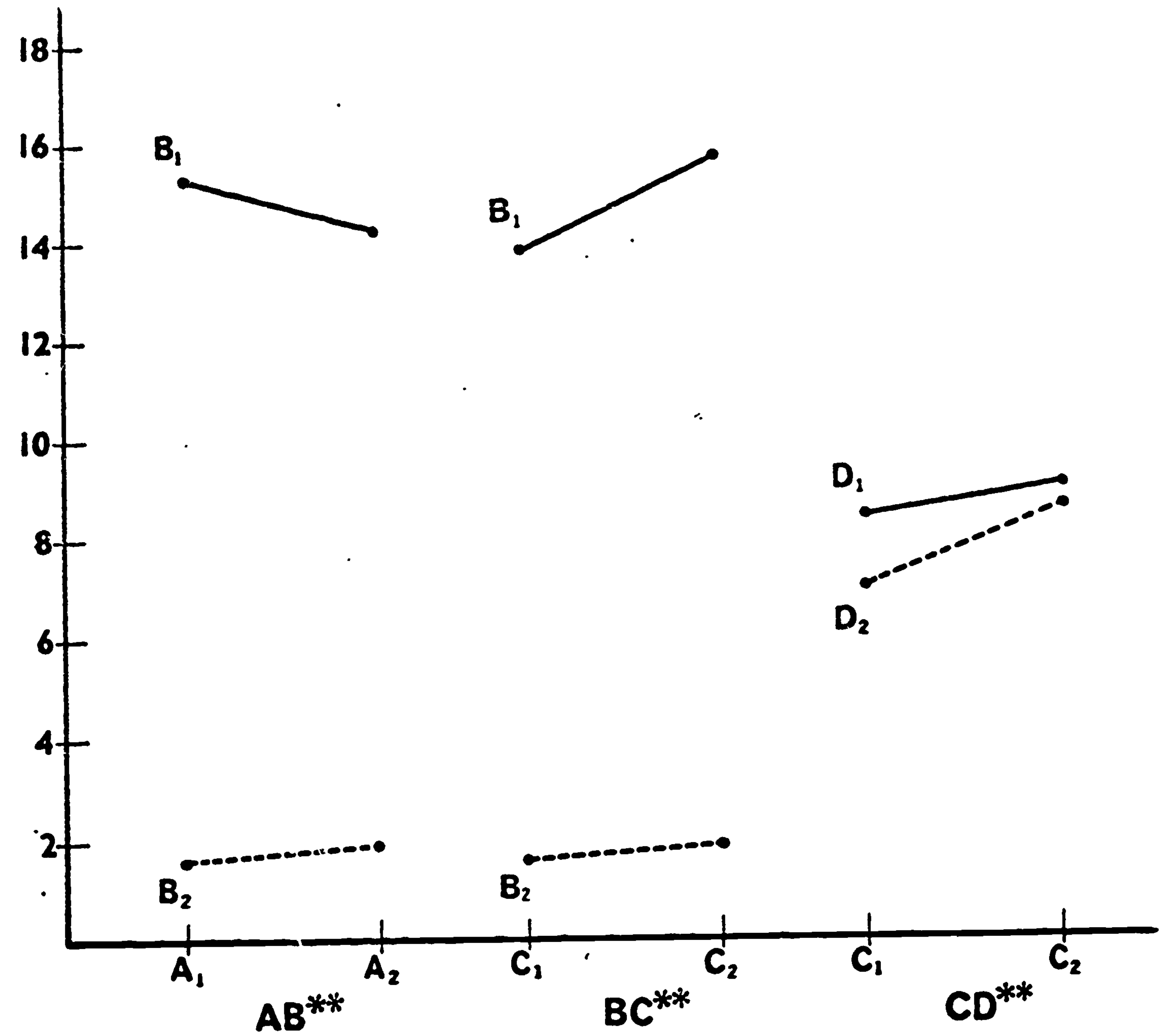
** = Significant at .01 Level of Confidence differed significantly from Level 2, geometric shapes. Thus, this null hypothesis was rejected. The evidence indicated that there was a difference in the degree of stimulus meaningfulness. The Ss remembered more simple objects than geometric shapes.

The fifth null hypothesis, labeled Factor B, checked for differences between Ss' average performance on prompted items as compared to non prompted items. As indicated in TABLE 4, Level 1, prompting, differed significantly from Level 2. Therefore, the fifth null hypothesis also was rejected. The effects of prompting were the most striking feature of the over-all study. Even with shields, the Ss did much better on prompted items than non prompted ones.

Tests of the Non-Predicted Interactions

Numerous statistically significant interactions appeared in the data from the experimental sessions. Each of the significant interactions, noted in TABLE 4, has been plotted and is presented in FIGURES 3, 4, 5, 6, and 7.

The significant two-way interactions are plotted in FIGURE 3. The AB interaction indicated that the Ss did better on prompted items in Film A than on prompted items in Film B. A small reverse trend for all non prompted items appeared. For the AB interaction Ss seemed to do slightly better on non prompted items in Film B than in Film A. The plotted BC interaction suggested that under all prompting conditions the Ss consistently responded correctly to more position questions than color questions. Under all non prompting conditions, the above trend also was evident, however, to a much lesser degree. A significant two-way interaction between Factors C and D also is illustrated by FIGURE 3. The graph denotes that Ss,



**Significant at the .01 level of confidence.

A_1 - Film A

A_2 - Film B

B_1 - Prompt

B_2 - No Prompt

C_1 - Color Question

C_2 - Position Question

D_1 - Simple Objects

D_2 - Geometric Shapes

FIGURE 3

CELL MEANS PLOTTED FOR SIGNIFICANT

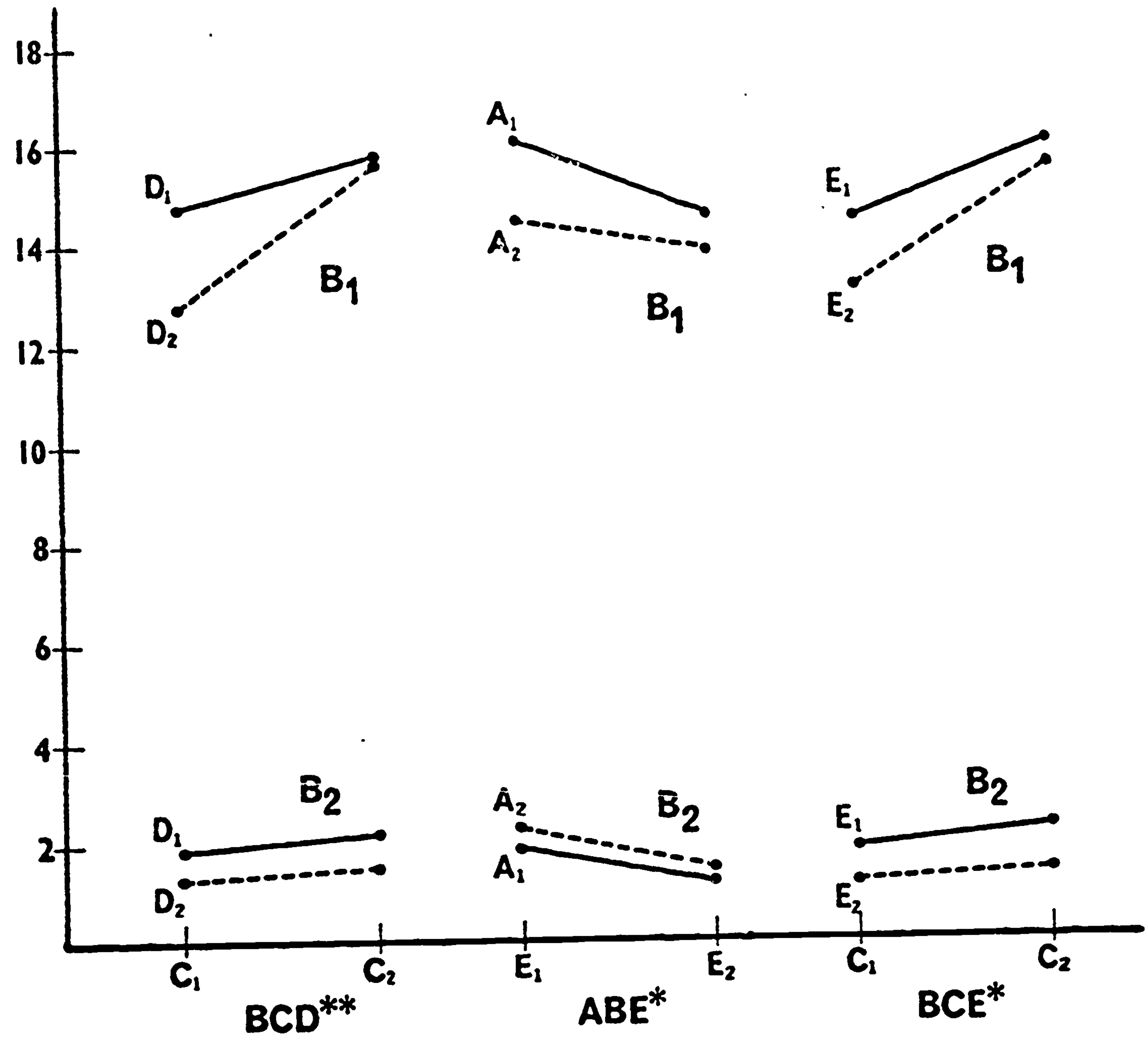
TWO WAY INTERACTIONS

under conditions requiring responses to color questions, received higher scores with simple object stimuli than with geometric shape stimuli. Under conditions of position questioning, this tendency was not as great. Thus, under conditions requiring responses to position questions, the Ss did almost as well on geometric shape stimuli as on simple object stimuli.

The prompting factor was prominent in the significant three-way interactions. They have been plotted and are found in FIGURES 4 and 5.

The plotted BCD interaction illustrates that under these conditions the Ss' mean score was higher for prompted items than for non prompted items. In addition, the Ss consistently responded higher on position questions than on color questions. Under conditions of prompting and when a color question was asked, the Ss' mean responses were higher for simple object stimuli than geometric shape stimuli. However, under conditions of prompting and when a position question was asked, the Ss' mean responses were highly similar for both simple object and geometric shape stimuli. This tendency was not consistent under non prompting conditions. For the non prompted items the Ss' mean responses also were higher for simple object stimuli than geometric shape stimuli. However, this tendency also held for position questions.

The plotted ABE interaction indicates that under these conditions the Ss scored considerably higher on prompted items than on non prompted items. Mean scores plotted for the prompted items of Films A and B indicate that under either high or low codable colored stimuli the Ss who viewed Film A had higher scores than the Ss who viewed Film B. The reverse was evident for non prompted items. The mean



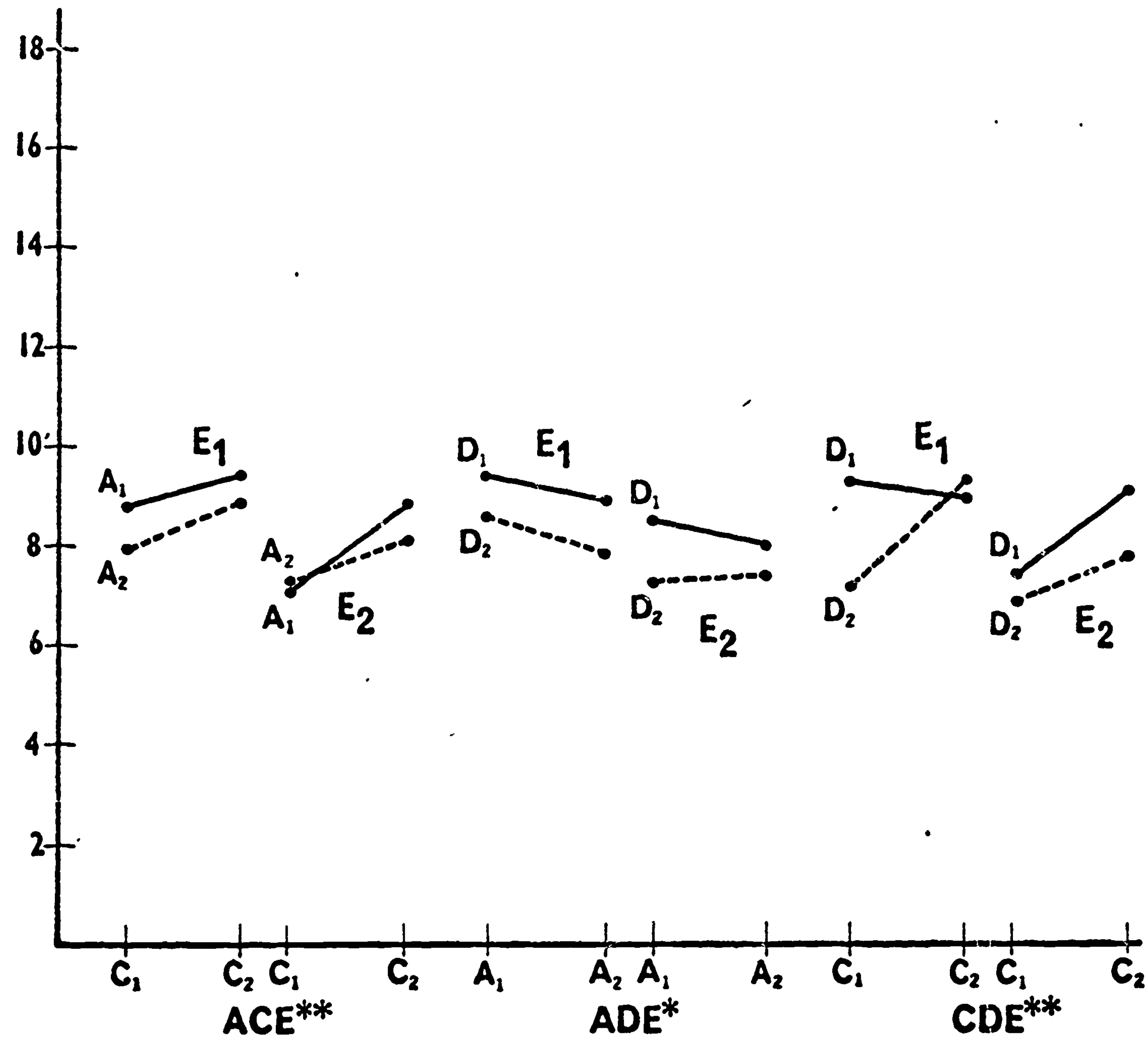
*Significant at the .05 level of confidence.
**Significant at the .01 level of confidence.

A_1 - Film A
A_2 - Film B
B_1 - Prompt
B_2 - No Prompt
C_1 - Color Question
C_2 - Position Question
D_1 - Simple Objects
D_2 - Geometric Shapes
E_1 - High Codability
E_2 - Low Codability

FIGURE 4

CELL MEANS PLOTTED FOR THE BCD, ABE, AND BCE

SIGNIFICANT THREE WAY INTERACTIONS



*Significant at the .05 level of confidence.
**Significant at the .01 level of confidence.

A_1 - Film A
A_2 - Film B
C_1 - Color Question
C_2 - Position Question
D_1 - Simple Objects
D_2 - Geometric Shapes
E_1 - High Codability
E_2 - Low Codability

FIGURE 5

CELL MEANS PLOTTED FOR THE ACE, ADE, AND CDE

SIGNIFICANT THREE WAY INTERACTIONS

scores plotted for the <u>non prompted</u> items denote that under either high or low codable colored stimuli the <u>S</u>s who viewed Film A had lower scores than the <u>S</u>s who viewed Film B. The same plots show that under <u>prompting</u> conditions for Film A, the <u>S</u>s' mean score was higher for high codable colored stimuli than for low codable colored stimuli. Under <u>prompting</u> conditions for Film B, this tendency was not as great. Also, under this condition the <u>S</u>s' mean score on low codable colored stimuli nearly matched their mean score on the high codable colored stimuli. Under the <u>non prompting</u> condition and for both Films A and B the <u>S</u>s' mean score was consistently higher for high codable colored stimuli than for low codable colored stimuli.

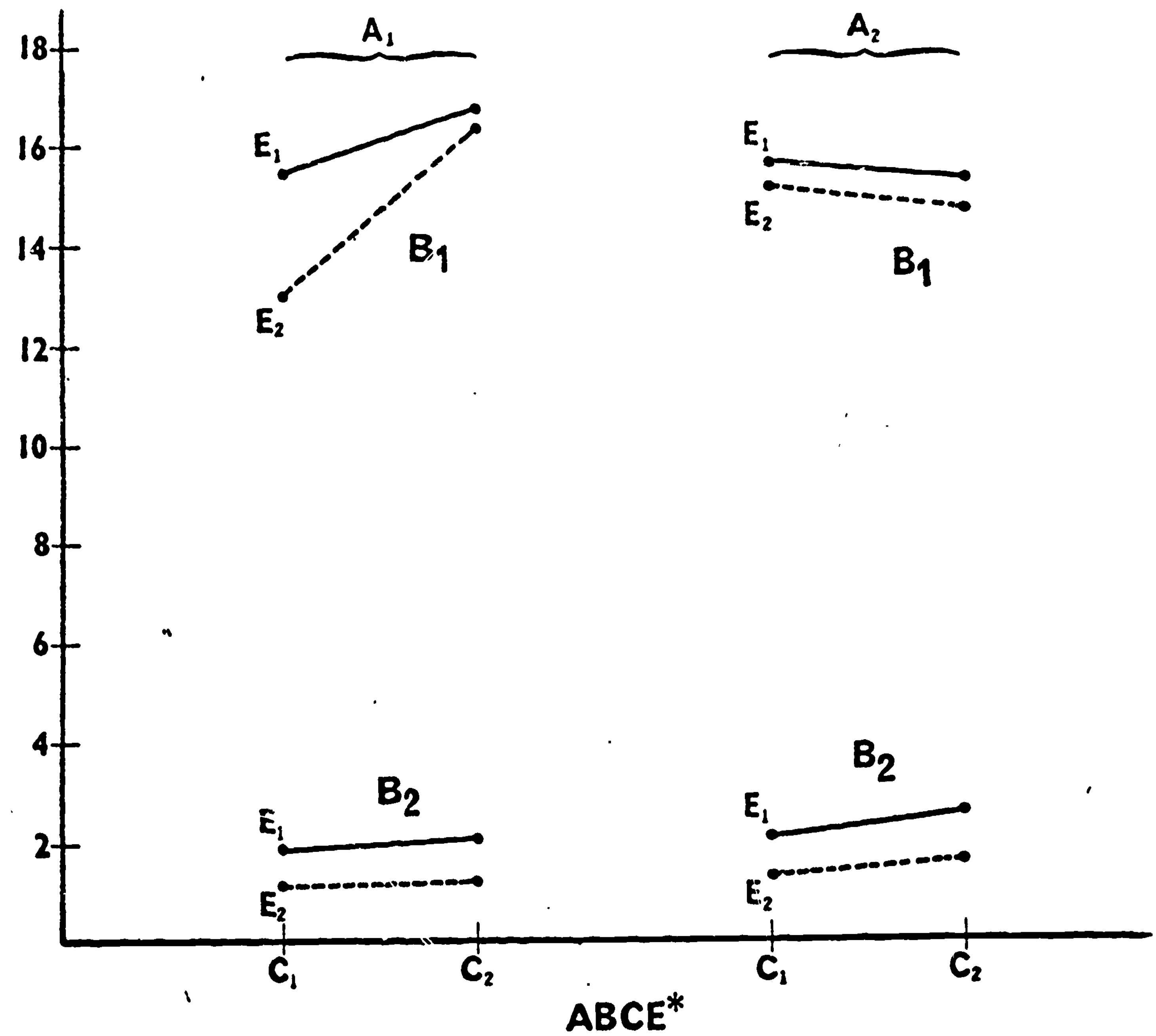
The plotted BCE interaction shows that <u>S</u>s' mean score was considerably higher for prompted items than non prompted ones. This plot shows that <u>S</u>s did better with position questions than color questions under prompting conditions. In addition, <u>S</u>s' scores were higher when high codable colored stimuli were used rather than low codable colored stimuli, regardless of the type of question asked.

FIGURE 5 illustrates other significant three-way interactions, however, these did not involve the prompting factor. It is indicated in the plotted ACE interaction that, in each film, and under either conditions of high codable colored stimuli, or low codable colored stimuli, the <u>S</u>s' mean score was higher with high codable colored stimuli than low codable colored stimuli. When high codable colored stimuli were used with <u>both</u> color and position questions the <u>S</u>s' mean scores on all questions were higher for Film A than for Film B. However, when low codable colored stimuli were used with both color and position questions the <u>S</u>s' mean scores were higher on color questions for Film B than for Film A. The reverse was true for position items when low codable colored stimuli were used.

The ADE interaction was plotted and appears in FIGURE 5. The graph denotes that in each film and under either conditions of high codable colored stimuli or low codable colored stimuli the Ss' mean scores were higher for questions requiring responses to simple objects than for questions requiring responses to geometric shapes. The highest plotted mean score was under conditions of Film B with high codable colored and simple object stimuli. The lowest plotted mean score was under conditions of Film B with low codable colored and geometric shape stimuli.

The CDE interaction was plotted and also appears in FIGURE 5. It is shown in the graph that under conditions of high codable colored stimuli and when a color question was asked, the Ss' mean scores were higher for simple object stimuli than for geometric shape stimuli. However, under conditions of high codable colored stimuli and when a position question was asked the Ss' mean scores were lower for simple object stimuli than for geometric shape stimuli. Under the low codable colored stimuli this reversal did not appear.

FIGURES 6 and 7 represent the two significant four-way interactions. The ABCE four-way interaction was plotted and is illustrated in FIGURE 6. In this graph the high and low codable colored stimuli were plotted under conditions of Films A or B, prompting or non prompting, and color or position questioning. The Ss' mean scores were higher for prompted questions than non prompted questions under any combination of Film A or B, high or low codable colored stimuli, and either color or position questions.



*Significant at the .05 level of confidence.

A_1 - Film A

A_2 - Film B

B_1 - Prompt

B_2 - No Prompt

C_1 - Color Question

C_2 - Position Question

E_1 - High Codability

E_2 - Low Codability

FIGURE 6

CELL MEANS PLOTTED FOR THE ABCE

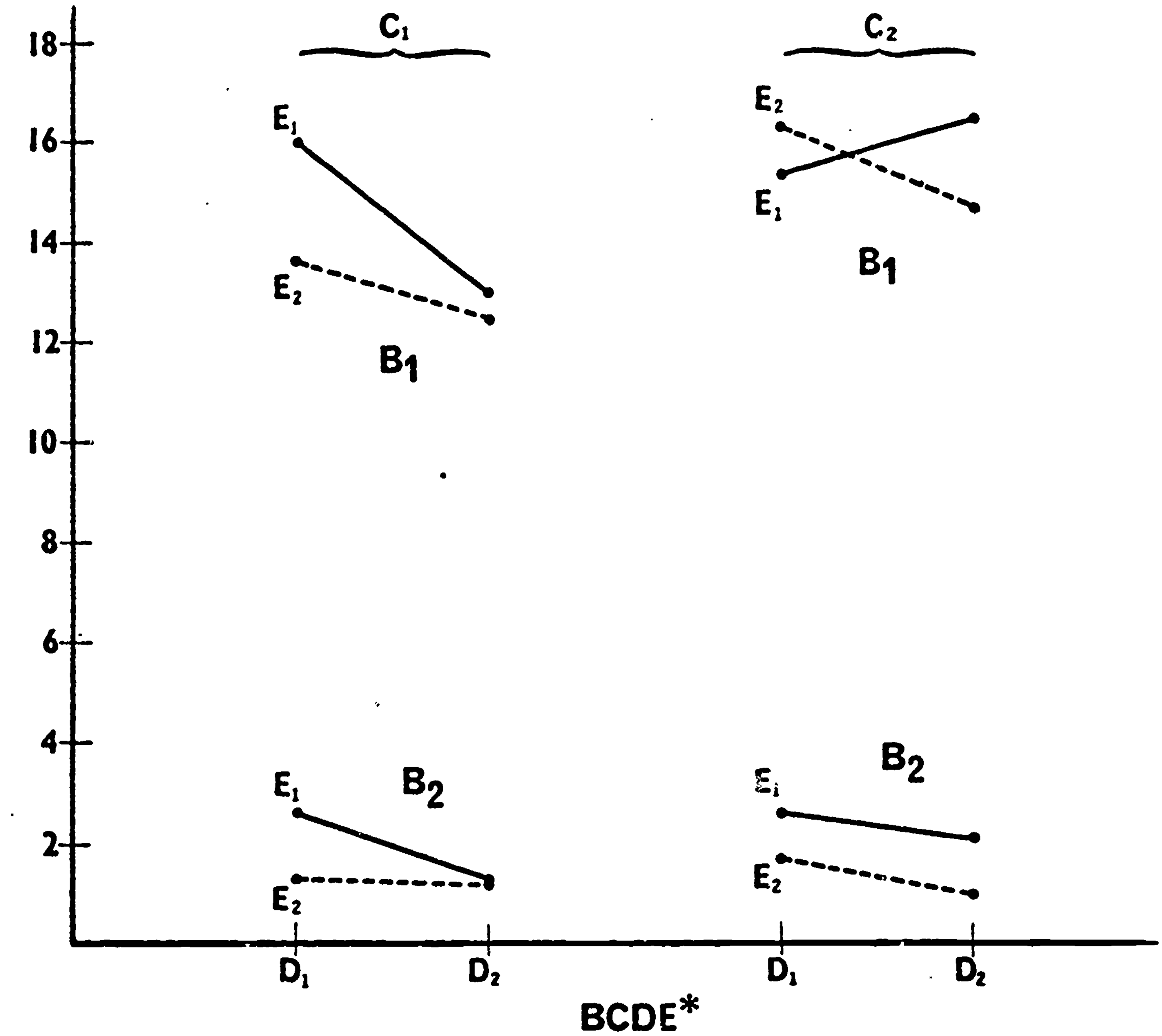
SIGNIFICANT FOUR WAY INTERACTION

The BCDE four-way interaction was plotted and is found in FIGURE 7. In this graph the high and low codable colored stimuli were plotted under conditions of prompting or non prompting, color or position questioning, and simple objects or geometric shapes. The Ss' mean scores were higher for prompted questions than for non prompted questions under any combination of questioning, high or low codable colored stimuli, and simple object or geometric shape stimuli.

Interpretations of Findings

Color codability. Brown and Lenneberg's findings indicated that color name length correlated with the time Ss required to recognize and respond to or name a color. Based on these response latencies, they labeled this factor "color codability." Results in the present study indicated that high codable colored stimuli were selected correctly more often than low codable colored stimuli. Thus, these results support, in part, Brown and Lenneberg's earlier research.

A check of the BCE interaction under prompting conditions indicated that the distance between points representing the high codable colored stimuli and the low codable colored stimuli was greater for the color questions than for the position questions. Thus, differences between performance on high and low codable colored stimuli were reflected under unusually easy conditions; i.e., under prompting and when color questions were asked. This trend was not evident for non prompted items. Perhaps differences in the trends between prompted and non prompted items were due to the relative low scores on non prompted items. It could have been impossible for trends to show when scores were so close to zero, as under non prompting, and by the same token when scores were unusually high as under prompted conditions.



*Significant at the .05 level of confidence.

B_1 - Prompt

B_2 - No Prompt

C_1 - Color Question

C_2 - Position Question

D_1 - Simple Object

D_2 - Geometric Shape

E_1 - High Codability

E_2 - Low Codability

FIGURE 7

CELL MEANS PLOTTED FOR THE BCDE

SIGNIFICANT FOUR WAY INTERACTION

The significant CDE interaction showed that under conditions of high codable colored stimuli and when a color question was asked, the Ss' mean scores were much higher for simple object stimuli than for geometric shape stimuli. However, under conditions of high codable colored stimuli and when a position question was asked the Ss' mean scores were lower for simple object stimuli than for geometric shape stimuli. Under the low codable colored stimuli, this reversal did not appear. However, for color questions, the spread between points representing scores of simple objects and geometric shapes was not as great as it was for position questions.

It was indicated by the data that in most instances Ss scored higher on high codable colored stimuli than on low codable colored stimuli. However, there was a wider spread between points representing scores of the high and low codable colored stimuli under conditions of Film A with prompted color questions. In other words, high codable colors seemed to be most effective when there is a prompted stimuli, a color question, and Ss responding to an array of color names.

The effects of color codability as defined by Brown and Lenneberg may have contributed to these findings. However, the colors used in the present study were checked against the Munsell notation scheme. The check revealed that the four low codable colors appeared to be on the average lighter in value than the high codable colors. In addition, the high codable colors appeared to be on the average higher in saturation than the low codable colors. In summary, it seemed that there may be basis to differentiate cue value of colors;

yet it has not been determined from this study exactly what aspect of color is being utilized by individuals in a learning environment.

Verbal cueing. According to Whorf, a language used or shared by individuals provides an essential coding system for efficient recognition, discrimination, and identification of stimuli. Past research by Jensen and Rohwer with the Stroop Color-Word Test generally agreed with Whorf's views. Their findings generally indicated that it took adult Ss more time to name common objects than to read the object's name. Jensen and Rohwer suggest that the verbal habit strength of responding to printed words is greater than the habit strength for responding to the actual objects or color patches.

In this research, differences in performance on named and non-named colors were not significant. However, when responding only to color questions, the Ss did slightly better over-all with color names than color patches. Perhaps, in the present study, responding to non-verbal stimuli was somewhat easier than under research conditions reported in previous studies. The Ss might have found it easier to match the color patch, rather than the color name, to the appropriately colored stimuli which had been presented immediately before hand. Evidence to support this idea was found in the AB two-way interaction. Under non prompting conditions, Ss did better on Film B, color patches, than Film A, color names. The ABE three-way interaction also illustrated that under non prompting conditions and under either high or low color codability levels, Ss had higher scores on Film B, color patches, than on Film A, color names. Thus, under moderately difficult conditions, it was easier to match colored stimuli to color patches than to color names. This could be due to similarity of format or eidetic memory which allowed the Ss to reconstruct the array. Thus, Jensen and Rohwer's findings may not be comparable in the present study.

Another factor which may have had some bearing on the over-all lack of differences in Ss' performance between Films A and B was that among Ss there may have been disagreement as to the color names selected by the experimenter for the low codable colors. This conflict may have lowered the Film A scores. However, Ss may have been in greater agreement with the color names selected for the high codable colors. This was illustrated by the ACE three-way interaction which showed that for low codable colored stimuli, about which color questions have been asked, Ss did better matching color patches than color names. The ACE interaction also showed that for high codable colored stimuli about which color questions were asked, Ss did better matching from color names than from color patches. Thus, perhaps memory matching of low codable colors; i.e., colored patch to colored stimuli under Film B conditions; was easier than matching selected low codable color names to colored stimuli as found under Film A conditions.

Information Processing. Information processing priorities that individuals might establish were considered in this study. Apparently, as results indicated, the stimulus feature selected for testing was related to Ss' test performance.

Over-all, the Ss received higher scores on position questions than on color questions. This also was noted in the numerous interactions which were found to be significant. These interactions indicated that, under prompting conditions, Ss' mean scores on position questions were considerably higher than their mean scores on color questions. Under non prompting conditions this degree of difference between color and position mean scores was not as great. Again, perhaps these differences between non prompted and prompted items were due to the relative low scores on non prompted items and the high scores on prompted items. Thus, the "true" trend may be distorted by the polarity of scores.

The significant CDE three-way interaction indicated that Ss responded better to color questions than to position questions under conditions of high codable colored, simple object stimuli. A similar tendency was noted in the data from the prompted high codable colored simple object stimuli items in the more complex four-way interactions.

Thus, under conditions of this study, it appeared that Ss generally attended to selected aspects of the stimulus field in an order of priority that would maximize their "payoff." It appeared that Ss utilized features which they felt they would most likely get correct because of reduced information processing requirements. First, they concentrated on prompted items since they would most likely get them correct. Second, Ss attended to position information, and finally, they quickly scanned colors. Even though many Ss may have over concentrated on the prompted items, this still did not account for the differences between position and color questioning. Perhaps Ss became discouraged with color items since they had to select one of eight color alternatives when presented with color questions. Thus, position items may have "seemed" easier to the Ss since they had to select one location from only four alternatives; i.e., less work.

However, it may be that position information more nearly matched the kinds of test questions Ss have experienced in the past. Color information, on the other hand, may have been less relevant in their previous testing experience. Support for this idea was presented by Otto and Askov (1968) since they cited several instances in past research where Ss preferred form or object cues over color cues.

Object Meaningfulness. In the present study, two different classifications of objects were included to see if shapes and forms have different effects on memory. The shapes selected for the study did affect Ss' utilization or memory of stimuli information. It appeared that, over-all, Ss were responding significantly better to simple object stimuli than to geometric shape stimuli.

The CD interaction illustrated that, for color questions in this research, Ss had higher scores for simple objects than for geometric shapes. In addition, there were greater differences between simple objects and geometric shapes on color questions than on position questions. The BCD interaction illustrated that, for color questions, the spread of scores between simple objects and geometric shapes was greater for prompted items than for non prompted ones. The CDE interaction illustrated that, for color questions, the spread of scores between simple object stimuli and geometric shape stimuli was much greater when high codable colors were used than when low codable colors were used.

Based on the higher recall for simple object stimuli, one might assume that the simple object stimuli were easier for the Ss to remember than the geometric shapes. If they were easier to remember, then perhaps they were more meaningful to the Ss. Thus, Ss may have had more meaningful past experience with objects similar to the simple object stimuli than with objects similar to the geometric shape stimuli. Perhaps the simple object stimuli provide a greater degree of association; thus Ss assimilated them quickly and remembered them longer than geometric shapes.

Prompting. In this study, prompting had an over-all dramatic and powerful impact on learning or recall of information. The large B main effect provided evidence that the power of this phenomenon in this research was much greater than anticipated. The most apparent finding of the total eleven significant interactions was that seven involved the prompting condition. The results suggested that prompting greatly reduced the amount of information that Ss had to assimilate. Non prompted items contained the same information, but all of it had to be scanned or assimilated quickly. As a result of prompting, Ss could concentrate on parts of the stimulus array thereby reducing decision uncertainty and the necessary decision time to respond. Another added element that might favor prompted items was the perceived degree of difference in difficulty level between prompted and non prompted items. Perhaps the prompted items were too easy, and by contrast, a feeling of frustration was produced in Ss as they faced even moderately difficult non prompted items which in turn caused them to respond carelessly or in a half motivated manner. The end result was poor, even chance, performance levels on non prompted items.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Statement of the Problem

This research was initiated to examine the extent to which undergraduate college students are affected by and remember color stimuli. Various colored objects or silhouettes were presented for testing in two films. In one film, Ss reacted to color names while in the other they responded to color chips. The filmed tests duplicated instructional film features where possible. Color characterized as low and high codable was included with silhouettes which represented certain simple objects and certain geometric forms. Some items asked questions about colors while other items quizzed Ss about position information. In addition, half of the items were prompted while the other half were not.

Design of the Study

Verbal cueing, prompting, type of question, stimulus silhouettes, and color codability represented the five factors studied in this research. These factors were developed into stimulus scenes for study via the 16mm motion picture film medium. All stimulus scenes or treatment conditions were randomized throughout each film to control for practice, fatigue, and other effects.

The statistical design used in this research was a multi-factor analysis of variance with repeated measures. Because of the reduced error variance, this design provided a greater possibility for detecting small differences. Also, this design was selected because it permitted an efficient use of Ss, and, in this study, order effects were small when compared to treatment effects. Finally, all factors were assumed to be fixed since the levels were selected by a systematic or non random procedure.

The 86 Ss used in the experimental sessions were male and female undergraduate students who volunteered for the experiment to fulfill a course requirement. All Ss selected for the experimental sessions were screened for color blindness with the Pseudo-Isochromatic Color Plates. Finally, the Ss were randomly assigned to one of the two experimental sessions with 43 Ss in each session.

Summary of Findings

There is no difference between Ss' average performance on high codable colors as compared to low codable colors. This hypothesis is rejected at the .01 level of confidence. It is indicated by the data that Ss scored higher on high codable colored stimuli than on low codable colored stimuli.

There is no difference between the mean criterion performance of Ss who viewed Film A as compared to Ss who viewed Film B. This hypothesis is not rejected. It is indicated by the data that the verbal cues or color names did not reinforce or add significantly to Ss' memory of colored stimuli.

There is no difference between Ss' average performance on color items as compared to position items. This hypothesis is rejected at the .01 level of confidence. It is shown by the results that Ss scored higher on position items than on color items.

There is no difference between Ss' average performance on simple objects as compared to geometric shapes. This hypothesis is rejected at the .01 level of confidence. It is indicated by the data that Ss scored higher on simple object stimuli than on geometric shape stimuli.

There is no difference between Ss' average performance on prompted items as compared to non prompted items. This hypothesis is rejected at the .01 level of confidence. It is indicated by the results that Ss scored higher on prompted items than on non prompted items.

Conclusions

The investigation pursued in this study appears to partially support the notion that colors have varying degrees of value as cues or aids to memory of stimulus information. The Ss, when responding to the high codable colored stimuli, had significantly higher scores than when responding to the low codable colored stimuli. From the significant interactions it is concluded that high codable colors are most effective under prompting conditions, with a position question and when Ss responded to an array of color names. This trend is not evident for non prompted items.

The present research provides little information as to the differences between responses to color names and color patches. The Ss apparently responded to color patch alternatives about as easily as the Ss who responded to color name alternatives. Thus, the theory that verbal cues; i.e., color names; would provide Ss with more usable information is not supported in this study. Perhaps a reason why Whorf's theory is not supported is due to the condition of "stimulus overload" that Ss experienced. Thus, color names become non functional in this task for Ss who already had a great deal of information to assimilate in a short period. Perhaps another reason is that, in the present study, responses to non verbal stimuli were somewhat easier than under earlier research conditions. The Ss might have found it easier to match the color patch, rather than the color name, to the appropriate colored stimuli. In addition, there may have been disagreement among Ss as to the color names assigned to the low codable colors. This possible conflict may have lowered the scores on the color name film task.

In the present study, Ss consistently scored higher on position items than on color items. Several studies, reported by Otto and Askov, (1968, pp. 155-164), have been conducted to check color or form preferences in matching tasks. Some studies indicated that Ss perform better on tasks in which they were prompted by color cues rather than shape or form cues while other studies indicated the reverse. Perhaps different individuals prefer different cues. Some individuals may like color cues while others may prefer form or shape cues.

It is concluded that Ss generally established priorities within a stimulus field to maximize or insure higher scores. They concentrated on features which they believed they would most likely get correct because of the reduced information processing requirements. Thus, position items may have seemed easier.

It is concluded that, over-all, Ss responded better to simple object stimuli than to geometric shape stimuli. The Ss may have had greater past experience with the simple object stimuli thereby, providing a greater degree of association. Thus, the Ss assimilated simple object stimuli quickly and remembered them longer than geometric shapes.

It is concluded that the prompted items were too easy and perhaps the non prompted items were too difficult. Thus, this contrast between item difficulty may have biased the findings in the present study. Prompting greatly reduced the amount of information that Ss had to assimilate. Thus, Ss probably perceived prompted items as being easy while non prompted items were considered overly difficult. This may have resulted in a lack of motivation among Ss when presented with non prompted items. The end result was poor performance on non prompted items.

It is concluded that interactions containing prompted and non prompted items are difficult to interpret. This is due to the relative high scores on prompted items and the relative low scores on non prompted items. It may be difficult to interpret trends when scores near the upper limits, as under prompting, or when scores are close to zero, as under non prompting.

Recommendations

Differences appear to exist between colors as they interact in instructional materials. Thus, it is recommended that the Brown and Lenneberg study be replicated. Perhaps latency measures should be taken again on the original 24 colors used in their study. A particular research strategy could be followed which would yield maximum information at minimal cost. First, comparisons between color chips should be made exactly as specified in the Brown and

Lenneberg study. Second, the 24 color chips should be still photographed with high quality color film so that 35mm color slides can be similarly compared. If there is a high degree of latency score correlation between the two methods, then the same procedure should be conducted with high quality 16mm color film. Thus, if similar high correlations are found between direct viewing of color chips and transparent color film, then statements about the effects of color codability on memory of filmed stimulus information could be made more readily. In addition, a study of the effects of color on memory between the direct viewing medium and the projected transparent image medium might be possible.

There appears to be a void in the literature when one examines the color codability factor. Perhaps there is a need for the development of a color codability scale since the color codability factor is not related to the Munsell notation system in any direct way. An interval or ratio scale might be helpful in terms of actually measuring the codability of a given color. Thus, further research is needed on the value of color cues in instructional materials. This view is supported by the work of Otto and Askov (1968). They state that:

> . . . color has been used to carry basic information, but little has been done to make use of the existing research, probably because the cue value of color in learning is still essentially unclear (p. 161).

Color versus position-form information was examined in the present study. It is recommended that future similar studies of information processing be conducted. However, the number of alternatives from which Ss must select should be equal for both color and position-form items. If a decision is made not to study position information, then it is recommended that the number of color alternatives from which Ss must select be reduced from eight to either four or five. Thus, if four colored objects are presented in a stimulus array, the same four colors should perhaps be used with four alternatives in the response section of the test.

It is indicated, from the results in the present study, that stimuli have differing effects on learning. It still is unclear whether this effect is related to the meaningfulness of stimuli. It is recommended that further research be conducted to determine the effects of stimuli meaningfulness on learning. Do some stimulus conditions provide greater meaning? If so, are they assimilated more quickly and remembered longer?

In future similar research involving prompting, it is recommended that the prompting condition be modified. The color testing films should be edited so that the prompt states something like the following: "Note the truck" rather than "Note the truck's color." An additional condition in the present study could have made the non prompted items even more difficult. Non prompted stimulus scenes may have flashed on the screen without Ss being aware they were there. What would be the effects of a prompt like an item number? Thus, the audio portion would always cue the Ss that another stimulus array was about to be presented; i.e., "Item 23." Perhaps, if the degree of differences between prompted and non prompted items was not as great, trends could be pictured more clearly. The interaction effects may be unclear when Ss score overly high on some items and at the same time below "normal" on other items. Thus, these interactions should be interpreted carefully.

Finally, for the practictioner, a statement by Otto and Askov, (1968, p. 164) seems most appropriate in terms of the effects of color in instructional materials.

> It seems clear that color cues tend to be most useful when other cues are minimal, but much of the existing confusion seems to arise from the fact that different age/ability/ skill development groups respond differently to available cues.

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APPENDICES

APPENDIX A

ITEMS ASSIGNED TO TREATMENT CONDITIONS WITHIN EACH FILM*

BCDE 1221	BCDE 2222	BCDE 2121	BCDE 1122	BCDE 2221	BCDE 1222	BCDE 1212	BCDE 2211	BCDE 2212	BCDE 1211	BCDE 2111	BCDE 1111	BCDE 2112	BCDE 2122	BCDE 1112	BCDE 1121
1	2	3	4	5	6	7	14	15	16	17	19	22	36	37	57
45	53	11	24	26	8	9	18	42	23	30	25	48	56	69	93
60	54	29	44	39	21	10	20	84	81	49	27	61	66	124	96
83	59	33	62	47	32	12	28	95	91	86	41	88	73	136	109
89	68	38	74	65	34	13	31	104	100	99	52	106	77	148	115
107	87	55	85	67	43	40	35	105	102	114	58	116	94	169	119
127	90	70	131	103	46	50	63	110	128	117	64	160	97	191	137
145	92	79	150	135	51	75	78	141	134	185	71	163	101	197	157
146	112	80	164	140	72	111	98	167	144	192	118	184	126	202	165
154	113	82	172	142	76	121	123	200	152	194	120	189	138	203	186
159	122	108	177	162	125	130	132	218	155	205	176	243	149	217	190
168	129	139	180	170	151	133	147	222	188	210	195	248	173	229	196
212	143	158	214	171	153	179	166	231	198	224	208	250	206	247	201
216	156	174	228	182	236	181	199	233	209	245	211	257	220	265	274
223	175	178	234	232	264	183	227	252	219	259	213	258	263	266	283
230	207	187	239	242	272	204	235	260	226	267	240	262	279	273	289
237	221	193	244	254	284	215	256	276	238	269	241	271	296	285	291
261	251	249	255	277	293	225	281	280	292	295	246	275	300	286	305
297	308	298	268	282	315	270	287	306	316	304	253	299	303	318	310
301		320	294	313	319	290	288	309		307	278		312		
317						302					311		314		

*The items are arranged under conditions by factor over level.

APPENDIX B

STORYBOARD SHEET

Background	Item Number	Object Location A	B	C	D	Frame Count	Audio

APPENDIX C

COLOR NAMING TASK

Your task is to determine appropriate names for each color chip in the display. Look at the display's eight colored chips. Note that each chip has a code letter. Now, look at the column of letters in the lower left of this sheet. There, record three names for each color.

	1st choice	2nd choice	3rd choice
A	______	______	______
B	______	______	______
C	______	______	______
D	______	______	______
E	______	______	______
F	______	______	______
G	______	______	______
H	______	______	______

APPENDIX D

RANKINGS FOR COLOR NAMING TASK

High Codable Colors

5Y 8/12	2.5YR 6/14	5YR 3/4	5PB 4/10
yellow - 22	orange - 28	brown - 25	blue - 23
chartreuse - 2	burnt orange - 3	chocolate brown - 3	royal blue - 7
yellow green - 1	tangarine - 1	chocolate - 1	bright blue - 1
mustard yellow - 1	pumpkin orange - 1	dark brown - 2	capri blue - 1
mustard - 1	rust - 1	cocoa brown - 2	dark blue - 1
deep yellow - 1		warm brown - 1	true blue - 1
medium yellow - 1			
sunshine - 1			
dirty yellow - 1			
pear yellow - 1			
bright yellow - 1			
yellow gold - 1			

Low Codable Colors

7.5R 8/4	5RP 6/10	7.5Y 6/8	2.5Y 7/10
pink - 21	rose - 13	green - 10	gold - 19
flesh - 5	pink - 7	olive green - 7	mustard - 4
flesh pink - 2	old rose - 2	olive - 3	mustard yellow - 2
light pink - 2	fuchia - 2	light olive green - 1	yellow gold - 1
pastel pink - 1	hot pink - 3	avacado - 3	old gold - 1
dusty pink - 1	light rose - 1	avacado green - 2	dirty gold - 1
rose beige - 1	orchid - 1	pea green - 2	federal gold - 1
salmon - 1	shocking pink - 1	moss green - 2	burnt gold - 1
	deep pink - 1	yellow green - 1	yellow - 1
	bright rose - 2	light green - 1	yellow brown - 1
		chartreuse - 1	maize - 1
		khaki - 1	tan - 1

APPENDIX E

COLOR NAMES USED IN FILM A

Color	Munsell Notation	Name
A	5Y 8/12	Yellow
B	2.5YR 6/14	Orange
C	5YR 3/4	Brown
D	5PB 4/10	Blue
E	7.5R 8/4	Pink
F	5RP 6/10	Rose
G	7.5Y 6/8	Green
H	2.5Y 7/10	Gold

APPENDIX F

Booklet Number____

PERSONAL INFORMATION BLANK

NAME:______________________ ____ ________________

LAST M. I. FIRST

AGE:______

SEX: MALE____ FEMALE____

MAJOR:______ ______________________________________

MINOR:____

SCHOOL YEAR AND SEMESTER:______________________________

STUDENT NUMBER:____________________

APPENDIX F

FILM A RESPONSE SHEET

Item	Position	Color	Item	Position	Color
1.	A B C D	yellow orange brown blue pink rose green gold	11.	A B C D	yellow orange brown blue pink rose green gold
2.	A B C D	yellow orange brown blue pink rose green gold	12.	A B C D	yellow orange brown blue pink rose green gold
3.	A B C D	yellow orange brown blue pink rose green gold	13.	A B C D	yellow orange brown blue pink rose green gold
4.	A B C D	yellow orange brown blue pink rose green gold	14.	A B C D	yellow orange brown blue pink rose green gold
5.	A B C D	yellow orange brown blue pink rose green gold	15.	A B C D	yellow orange brown blue pink rose green gold
6.	A B C D	yellow orange brown blue pink rose green gold	16.	A B C D	yellow orange brown blue pink rose green gold
7.	A B C D	yellow orange brown blue pink rose green gold	17.	A B C D	yellow orange brown blue pink rose green gold
8.	A B C D	yellow orange brown blue pink rose green gold	18.	A B C D	yellow orange brown blue pink rose green gold
9.	A B C D	yellow orange brown blue pink rose green gold	19.	A B C D	yellow orange brown blue pink rose green gold
10.	A B C D	yellow orange brown blue pink rose green gold	20.	A B C D	yellow orange brown blue pink rose green gold

APPENDIX F

FILM B RESPONSE SHEET

Item	Position	Color				Item	Position	Color			
1.	A	[]	[]	[]	[]	7.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		B C D	[]	[]	[]	[]
2.	A	[]	[]	[]	[]	8.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		B C D	[]	[]	[]	[]
3.	A	[]	[]	[]	[]	9.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		B C D	[]	[]	[]	[]
4.	A	[]	[]	[]	[]	10.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		B C D	[]	[]	[]	[]
5.	A	[]	[]	[]	[]	11.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		P C D	[]	[]	[]	[]
6.	A	[]	[]	[]	[]	12.	A	[]	[]	[]	[]
	B C D	[]	[]	[]	[]		B C D	[]	[]	[]	[]

APPENDIX G

1. There is no systematic pattern in which stimulus objects, colors, or cues will be presented. These conditions are random.
2. The backgrounds are consistent. They always appear in a given order for both information and test scenes. Use the backgrounds to aid your recall of objects, colors, and locations.
3. Each information array will be presented for two seconds while each test scene will appear for eight seconds.
4. Look at the screen after you have answered an item or you could miss the next stimulus scene since every item is not prompted.
5. Due to limitations in processing techniques, there may be places where the colors will be lighter or darker. These were intended to be the same colors you saw previously but some phase of processing may have changed a few of them.
6. Is everyone comfortable? Can you see the screen? Is your pencil sharp, and is your booklet on Page 1? Are you ready?
7. Item 1 will appear as soon as the projector starts.

APPENDIX H

COMPUTING THE HARMONIC MEAN

$$\tilde{n} = \frac{k}{(1/n_1) + (1n_2) + . . . + (1+n_k)}$$

$$\tilde{n} = \frac{16}{\frac{1}{21} + \frac{1}{19} + \frac{1}{20} + \frac{1}{20} + \frac{1}{20} + \frac{1}{20} + \frac{1}{21} + \frac{1}{20} + \frac{1}{20} + \frac{1}{19} + \frac{1}{20} + \frac{1}{21} + \frac{1}{20} + \frac{1}{21} + \frac{1}{19} + \frac{1}{19}}$$

$$\tilde{n} = \frac{16}{.0476 + .0526 + .05 + .05 + .05 + .05 + .0476 + .05 + .05 + .0526 + .05 + .0476 + .05 + .0476 + .0526 + .0526}$$

$$\tilde{n} = \frac{16}{.800}$$

$$\tilde{n} = 20$$